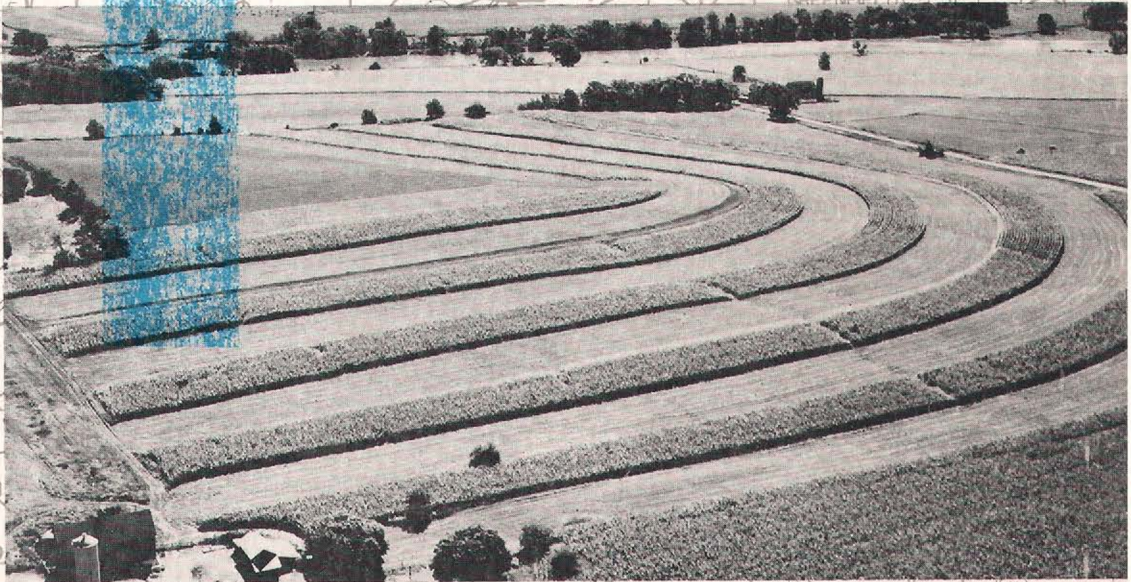
PLANNING REPORT NO. 30

# A REGIONAL WATER QUALITY MANAGEMENT PLAN FOR SOUTHEASTERN WISCONSIN -- 2000



## volume two

## ALTERNATIVE PLANS

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Planning Report No. 30

# A REGIONAL WATER QUALITY MANAGEMENT PLAN FOR SOUTHEASTERN WISCONSIN: 2000

Volume Two

## ALTERNATIVE PLANS

Prepared by the

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P. O. Box 769
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February 1979

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## STATEMENT OF THE CHAIRMAN

In accordance with Public Law 92-500, the Clean Water Act, and upon the Commission being designated by the Governor as the areawide water quality management planning agency, the Commission undertook on July 1, 1975, the preparation of an areawide water quality management planning program. The findings and recommendations of this program are documented in a three-volume report. The first volume presents a summary of the findings of the many inventories required to provide the factual basis for determining how best to achieve the Congressionally mandated national goal of "fishable and swimmable" water quality in the 1,180 miles of streams and 100 major lakes within the Region. This, the second volume, sets forth the objectives that the areawide water quality management plan seeks to achieve, together with supporting principles and standards. It also presents forecasts of probable future conditions that must be considered in the design of alternative plans to provide clean and wholesome surface waters. Emphasis, however, is on the identification and evaluation of the alternative means available for abating water pollution and meeting the specified water use objectives under existing and probable future conditions within the Region. A comparison of existing and probable future water quality conditions under stated alternative plans is a particularly important part of this plan evaluation.

Extensive water resources planning efforts have already been accomplished by the Commission. In the alternative analysis process, there was reliance upon such plans as the regional land use plan, the various comprehensive watershed plans, the regional sanitary sewerage system plan, and the regional park and open space plan. The alternative plans presented herein constitute, in effect, a series of policy alternatives derived from detailed point source, nonpoint source, and sludge management elements. These are discussed in the summary chapter of this volume, and are intended to be helpful to more fully understanding the implications of the basic findings of the areawide water quality management planning program. The presentation of these policy alternatives includes a comparison of existing water quality conditions to such conditions under a "do nothing" alternative, an "intensive point source control" alternative, an "intensive nonpoint source control" alternative, and a "maximum practicable point and nonpoint source control" alternative. The information presented in this volume is intended to help policymakers select the best plan from among the alternatives available. That plan is presented in the third and final volume of the planning report, together with the recommended means for implementation.

Because of the advisory role of the Commission, the plan recommendations set forth in Volume Three must be viewed in the context of the extensive technical work and factual data which underlie those recommendations. Accordingly, the Commission recommends that the information contained in this report on the advantages, disadvantages, and costs of each alternative evaluated be carefully considered by those officials and interested citizens who will be involved in plan adoption and implementation.

Respectfully,

George C. Berteau,
Chairman

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## Chapter I

## INTRODUCTION

This chapter begins the second of three volumes which together comprise the major findings and recommendations of the southeastern Wisconsin areawide water quality management planning program. The first volume sets forth the basic principles and concepts underlying the study and presents a summary of the relationship of the water quality management program to other plans for the physical development of the Region; describes the existing natural and man-made features of the Region which affect, and are affected by, water quality; describes the existing level of water quality in the lakes and streams of the Region; and sets forth the legal and financial structures which are available to support water quality management measures. This, the second volume of this report, sets forth regional water quality and water quality-related development objectives, principles, and standards; discusses the growth and changes in population, economic activity, and land use development which may be expected and have been planned to occur within the Region; and describes alternative plans to meet the water quality objectives. Importantly, this volume summarizes the water quality effects and the costs of the alternative plans considered and discusses the factors considered in arriving at a recommended water quality management plan for the Region.

The third and final volume of this report presents the recommended plan together with recommendations concerning the means for its staged implementation over time. An environmental assessment of the recommended regional water quality management plan is included as an appendix to the third volume.

The alternatives presented in this the second volume were developed utilizing a seven-step planning process by which the factors affecting water quality can be described and alternative plans for pollution abatement formulated and evaluated. The seven steps involved in this planning process are: 1) study organization and design, 2) formulation of objectives and standards, 3) inventory, 4) analyses and forecasts, 5) plan design, test, and evaluation, 6) plan selection and adoption, and 7) plan implementation. Volume One of this report dealt with the first and third steps in this planning process. Volume Three will deal with the final two steps of the process. This volume deals with steps two, four, and five: formulation of objectives and standards, analyses and forecasts, and plan design, test, and evaluation.

A brief description of each of the seven steps comprising the planning process is contained in Chapter II of the first volume of this report, together with a statement of the basic principles and concepts underlying the water quality planning process and a discussion of the watershed as a rational water resources planning unit within the Region. Reconsideration of, and elaboration on, the three steps in the planning process with which this volume is concerned is warranted here.

### FORMULATION OF OBJECTIVES AND STANDARDS

It was noted in Volume One of this report that planning is a rational process for formulating and meeting objectives. Therefore, the formulation of objectives is an essential task which must be undertaken before plans can be prepared. The objectives chosen guide the preparation of alternative plans and, when converted to standards, provide the criteria for evaluating and selecting from among the alternatives. Since objectives provide the logical basis for plan synthesis, the formulation of sound objectives is a crucial step in the planning process. Yet the process of formulating objectives has received relatively little attention in most planning operations. The lack of a comprehensive and tested approach to the formulation of objectives and the inherent difficulty of resolving the problem of conflicting objectives are not sufficient reasons for neglecting in any planning operation this fundamental endeavor.

It is important to recognize that objectives implicitly reflect an underlying value system, because the formulation of objectives involves a formal definition of a desirable physical system by listing, in effect, the broad needs which the system aims to satisfy. Thus, every physical development plan is accompanied by its own unique value system. The diverse nature of value systems in a complex urban society complicates the process of goal formulation and makes it one of the most difficult tasks of the planning process. This difficulty reflects the absence of a clear-cut basis for a choice between value systems as well as the reluctance of public officials to make an explicit choice of ultimate goals. Yet it is even more important to choose the "right" objectives than to choose the "right" plan. To choose the wrong objectives is to solve the wrong problem; to choose the wrong plan is merely to choose a less efficient physical system. While, because of differing value systems, there may be no single argument to support the given choice of objectives, it is possible to state certain planning principles which provide at least some support for the choice, and this has been done herein.

Objectives cannot be intelligently chosen without knowledge of the crucial relationships existing between objectives and means. This suggests that the formulation of objectives is best done by people with prior knowledge of the social, economic, and technical means of achieving objectives, as well as of the underlying value systems. Even so, it must be recognized that objectives may change as means or plans are selected from among alternatives. In the process of evaluating alternative plans, the various alternative plan proposals are ranked according to ability to meet objectives. If the best plan so identified nevertheless falls short of the chosen objectives, either a better plan must be synthesized or the objectives must be compromised. The plan evaluation provides the basis for deciding which objectives to compromise. Compromises may take three forms: certain objectives may be dropped because satisfaction has been proven unrealistic; new objectives may be suggested; or conflicts between inconsistent objectives may be balanced out. Thus, formulation of objectives must proceed hand in hand with plan design and plan implementation as a part of a continuing planning process.

Concern for objectives cannot end with a mere listing of desired goals. The goals must be related in a demonstrable and, wherever possible, quantifiable manner to physical development proposals. Only through such a relationship can alternative development proposals be properly evaluated. This relationship is accomplished through a set of supporting standards for each chosen objective.

Because of the value judgments inherent in any set of development objectives and their supporting standards, soundly conceived water quality objectives, like regional development objectives, should incorporate the combined knowledge of many people who are informed about the regional water quality system. Furthermore, these water quality objectives should be established by duly elected or appointed representatives legally assigned this responsibility rather than solely by planners and engineers. Active participation by duly elected or appointed public officials and by citizen leaders in the regional planning program is implicit in the structure and organization of the Regional Planning Commission. Moreover, the Commission has provided for the establishment of advisory committees to assist it in the conduct of the regional planning program, including the areawide water quality management planning program, thereby broadening the opportunities for active participation in the regional planning effort.

The use of these advisory committees, together with appropriate public informational meetings and hearings, appears to be the most practical and effective way available to involve officials, professionals, technicians, and citizens in the regional planning process and to openly arrive at decisions and action programs which can shape the future physical development of the Region and the quality of its water resources. Only by combining the accumulated knowledge and experience which the various advisory committee members possess can a meaningful expression of desired direction, and magnitude, of future regional water quality management be attained. One of the major tasks of these advisory committees, therefore, is to assist the Commission in the formulation of development objectives, supporting principles, and standards. Chapter II of this volume sets forth the regional water quality management planning objectives, principles, and standards which have been adopted by the Commission after careful review and recommendation by the advisory committees concerned.

## ANALYSIS AND FORECASTS

Volume One of this report noted that analyses and forecasts are necessary to estimate and evaluate future conditions which affect water quality. Historical inventories provide knowledge of past and present physical and economic systems and their effects on water quality. Forecasts of these same systems allow estimations of future water quality conditions to be prepared and compared to the established objectives and standards. Where projected water quality fails to meet the objectives, water quality control facilities and regulations can be designed to meet future as well as present needs wherever adequate forecasts are available.

To analyze future water quality conditions, it is necessary to forecast the population and economic activity levels and land use conditions which will affect water quality conditions, water quality management efforts, and the public financial resources which are expected to be available to fund the water quality management measures recommended. The Commission has prepared forecasts of these parameters as a part of its ongoing regional planning program, and these forecasts together with a description of the techniques utilized in their preparation have been documented in other Commission reports.[1] Good planning practice, as well as federal regulations, requires forecasts used in the regional water quality management planning to be compatible with those used in the preparation of other regional plan elements, particularly the regional land use plan. Consequently, the Commission forecasts were utilized in the areawide water quality management planning program and are described herein in summary form.

It should be noted here that water quality control facilities, like other public works facilities, must be planned for anticipated demand at some specific future point in time. The target year for the plans is usually established by the expected life of the first facilities to be constructed in implementation of the plan. Although it may be argued that the design year for some facilities which seldom require replacement, such as trunk sewers, should be extended farther into the future than for less durable facilities, such as treatment plants, practical considerations dictate that the design year for all components of the plan be compatible, and, more importantly, be related to the design year for the underlying, areawide land use plan. Careful analysis of design year considerations was undertaken in the establishment of the basic principles and concepts for the areawide water

[1] *See SEWRPC Technical Report No. 10, The Economy of Southeastern Wisconsin, December 1975; SEWRPC Technical Report No. 11, The Population of Southeastern Wisconsin, December 1972; and SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000; Volume Two, Alternative and Recommended Plans, May 1978.*

quality management planning program, as presented in Volume One, Chapter II of this report. This analysis determined that the design year for the program should be the year 2000—a design year common to the new regional land use and transportation plans completed and adopted by the Commission in 1978.

## PLAN DESIGN, TEST, AND EVALUATION

It was noted in Volume One of this report that plan synthesis and test form the heart of the planning process and that the water quality management plan design problem consists essentially of determining from among the alternatives available the most cost-effective means of abating water pollution and thereby achieving the established water use objectives and supporting standards. The task of designing the two major components of the physical system which controls water quality—the nonpoint source control component and point source control component—is a complex and difficult problem. Not only does each component constitute in itself a major plan design problem in terms of its sheer size, but the pattern of interaction between the components is also exceedingly complex and dynamic. The nonpoint source control component must control pollutants entering streams from diffuse sources so as to meet established water use objectives without restricting the use of the land in a manner unacceptable to the public. It must, while meeting water use objectives, minimize conflicts between urbanization, agricultural production, and water quality; maintain an ecological balance for human, animal, and plant life; and prevent the creation of public health hazards. The point source control component must provide for the collection and treatment of the wastewaters and attendant pollution loadings and for the handling and disposal of the resultant residual solids generated by the resident population and economic activities of the Region to a degree which enables streams to meet agreed-upon water use objectives while maximizing the use of existing facilities and minimizing overall costs.

The magnitude of such a design problem nearly reaches an insoluble level of complexity; yet, no substitute for intuition in plan design has so far been found, much less developed to a practical level. Means do exist, however, for reducing the gap between the necessary intuitive and integrative grasp of the problem and its growing magnitude; and these means have been applied to the fullest extent presently possible in the regional water quality management study. These means center primarily on the application of systems engineering techniques to the quantitative test of both the nonpoint and point source control plan elements. Yet the quantitative tests involved, while powerful aids to the determination of the adequacy of the plan design, are of limited usefulness in actual plan synthesis. Consequently, it is still necessary to develop the plans by traditional intuitive "cut-and-try" methods and to quantitatively test the resulting design by application of simulation techniques where applicable, and to then make necessary adjustments in the design until a workable plan has been evolved. Finally, and most importantly, it should be noted that in both diffuse source and point source facility plan synthesis the Commission had at its disposal far more definitive information bearing on the problem than has ever before been available. This fact alone has made the traditional plan synthesis techniques applied more powerful and useful.

If the plans developed in the design stage of the planning process are to be practical and workable and thereby realized, some techniques must be applied to quantitatively test the feasibility of alternative measures in advance of their adoption and implementation. A plan subelement must be sequentially subjected to several levels of review and evaluation including technical and economic feasibility; financial, legal, and administrative feasibility; and political acceptability. Devices used to test and evaluate alternative plan elements range from mathematical models used to simulate water quality response in rivers and lakes to interagency meetings and public hearings. To assist in a quantitative analysis of the engineering performance and technical and economic feasibility of the alternative plan elements considered, hydrologic, hydraulic, and water quality models were developed and applied in the study. Test and evaluation, beyond the quantitative analyses permitted by the model application, involved an economic analysis of alternative subelements and a qualitative evaluation both of the degree to which each alternative water quality control plan subelement met development objectives and standards and of the legal feasibility of the alternatives.

## SCHEME OF PRESENTATION

The succeeding chapters of this volume set forth the findings of the three steps of the planning process as applied in the areawide water quality management planning program. Chapter II of this volume sets forth the objectives, principles, and standards which provided the basis for plan design and evaluation. Chapter III describes the forecast and planned changes in population, economic activity, and land use which are to be accommodated in the plan. Finally, in Chapter IV and in Appendix C the development and evaluation of alternative plans for point and nonpoint source control—plans which must be combined to form a comprehensive areawide water quality management plan—are presented. In its entirety, this second volume of the final planning report setting forth the findings and recommendations of the water quality management planning program for southeastern Wisconsin is intended to provide the foundation for the development, test, and evaluation of alternative water quality management plans, and for the selection of a recommended areawide water quality management plan from among those alternatives.

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## Chapter II

## WATER QUALITY MANAGEMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

### INTRODUCTION

Because planning is a rational process for formulating and meeting objectives, the formulation of objectives must be undertaken before plans can be prepared. Because many diverse and sometimes conflicting interests are represented within the seven-county Southeastern Wisconsin Region, the formulation of objectives presents a particularly difficult challenge. Because the formulation of objectives involves a formal definition of a desirable physical system of listing, in effect, the broad needs which the system aims to satisfy, objectives implicitly reflect an underlying value system. Thus, every physical development plan is accompanied by its own unique value system. The diverse nature of value systems in a complex urban society complicates the process of goal formulation and makes it one of the most difficult tasks of the planning process. This difficulty reflects, in part, the absence of a clear-cut basis for a choice between value systems and, in part, the reluctance of public officials to make an explicit choice of ultimate goals. Yet, it is more important to choose the "right" objectives than to choose the "right" plan. To choose the wrong objectives is to solve the wrong problem; to choose the wrong plan is merely to choose a less efficient physical system.

Sound development objectives for the Region should be based upon and incorporate the combined knowledge of many people who are well informed about the Region and its existing and potential environmental and developmental problems. The active participation by elected and appointed public officials and by citizen leaders in the goal formulation process is implicit in the structure of the Regional Planning Commission itself and in the advisory committees which the Commission has created to assist it in its work. In this respect, the Technical Advisory Committee on Areawide Wastewater Treatment and Water Quality Management Planning is only one of many advisory committees which have contributed to the formulation of regional development objectives. Other committees which have participated in previous goal formulation activities which have a direct bearing on the objectives, principles, and standards set forth herein have been the Technical and Citizen Coordinating and Advisory Committees on Regional Land Use-Transportation Planning, which jointly contributed to the formulation of regional land use and supporting transportation system development objectives; the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning, which contributed to the formulation of sanitary sewerage system development objectives; and the Root, Fox, Milwaukee, Menomonee, and Kinnickinnic River Watershed Committees, which contributed to the formulation of water use and water control facility objectives for the respective watersheds. In addition, the Technical Coordinating and Advisory Committee on Regional Air Quality Maintenance Planning has adopted by reference the federal ambient air quality standards which relate to the broad objectives of protecting the public health and welfare as part of the regional air quality maintenance plan. This chapter sets forth the regional development objectives, principles, and standards relevant to sound, areawide water quality management planning which have been adopted by the Commission under other planning programs after careful review and recommendation by the advisory committees concerned. In addition, a series of new objectives, principles, and standards directly related to the management of water quality within the Region is presented.

### BASIC CONCEPTS AND DEFINITIONS

The term "objective" is subject to a wide range of interpretation and application, and is closely linked to other terms often used in planning work which are equally subject to a wide range of interpretation and application. The following definitions have, therefore, been adopted by the Commission in order to provide a common frame of reference:

1. Objective: a goal or end toward the attainment of which plans and policies are directed.

2. Principle: a fundamental, primary, or generally accepted tenet used to support objectives and prepare standards and plans.

3. Standard: a criterion used as a basis for comparison to determine the adequacy of plan proposals to attain objectives.

4. Plan: a design which seeks to achieve the agreed-upon objectives.

5. Policy: a rule or course of action used to ensure plan implementation.

6. Program: a coordinated series of policies and actions to carry out a plan.

Although this chapter deals primarily with the first three of these terms, an understanding of the interrelationship of the foregoing definitions and the basic concepts which they represent is essential to the following discussion of development objectives, principles, and standards.

### WATER USE, QUALITY, AND MANAGEMENT OBJECTIVES

In order to be useful in the preparation of an areawide water quality management plan, objectives must be logically sound and related in a demonstrable and measurable way to alternative water quality management proposals. Only if the objectives are clearly related in a measurable manner to alternative management proposals can an intelligent choice be made from among alternative plans of the one plan which best meets the agreed-upon objectives.

Because water quality is so essential to the continued sound social and economic development of the Region, as well as to the protection of the underlying and sustaining natural resource base, it is essential that the water quality management objectives be consistent with other regional development objectives. Specifically, the previously adopted regional development objectives to be integrated into the areawide water quality management planning effort are those pertaining to land use development, water control facility development, sanitary sewerage system development, wastewater sludge management systems development, and water quality. All of these pertain directly to the abatement of water pollution and management of water quality within the Region.

In its planning efforts to date the Commission has adopted, after careful review and recommendation by the various advisory committees concerned, nine specific regional land use development objectives, four specific water control facility development objectives, four specific sanitary sewerage system development objectives, and six specific wastewater sludge management systems development objectives. In addition, seven water use objectives and supporting standards have been adopted for the various reaches of the stream and lake systems of the Root, Fox, Milwaukee, Menomonee, and Kinnickinnic River watersheds. These specific development objectives, together with their supporting principles and standards, are set forth in full in other Commission planning reports.[1]

Land Use Development Objectives

Six of the nine specific regional land use development objectives already adopted by the Commission under previous planning programs are applicable to the regional water quality management planning effort, and are hereby reaffirmed as development objectives under this planning program. These are:

1. A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population.
2. A spatial distribution of the various land uses which will result in a compatible arrangement of land uses.
3. A spatial distribution of the various land uses which will result in the protection and wise use of the natural resources of the Region including its soils, inland lakes and streams, wetlands, woodlands, and wildlife.
4. A spatial distribution of the various land uses which is properly related to the supporting transportation, utility, and public facility systems in order to assure the economic provision of transportation, utility, and public facility services.
5. The preservation and provision of open space to enhance the total quality of the regional environment, maximize essential natural resource availability, give form and structure to urban development, and facilitate the ultimate attainment of a balanced year-round outdoor recreation program providing a full range of facilities for all age groups.
6. The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture, provide a reserve or holding zone for future needs, and ensure the preservation of those unique rural areas which provide wildlife habitat and which are essential to shape and order urban development.

In addition to the foregoing six specific regional land use development objectives, the following specific land use development objective was adopted for the Milwaukee River watershed in the development of a comprehensive plan for that watershed and is hereby expanded, reaffirmed, and included as a development objective for the Region as a whole.

7. The attainment of good soil and water conservation practices on both rural and urban land in order to reduce storm water runoff; soil erosion; and stream and lake sedimentation, pollution, and eutrophication.

Water Control Facility Development Objectives

Three of the four water control facility development objectives already adopted by the Commission under its comprehensive watershed planning programs are applicable to the regional water quality management planning effort and are reaffirmed and included as specific development objectives for the water quality management planning program. These are:

1. Attainment of sound groundwater resource development and protective practices to minimize the possibility for pollution and depletion of the groundwater resources.
2. An integrated system of land management and water quality control facilities and pollution

[1] *See SEWRPC Planning Report No. 25, A Regional Land Use and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative and Recommended Plans; SEWRPC Planning Reports Nos. 9, 12, 13, 26, and 32, Comprehensive Plans for the Root, Fox, Milwaukee, Menomonee, and Kinnickinnic River watersheds, respectively; SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin; and SEWRPC Planning Report No. 29, A Regional Wastewater Sludge Management Plan for Southeastern Wisconsin.*

abatement devices adequate to ensure a quality of surface water necessary to meet the established water use objectives.

3. An integrated system of land management and water quality control facilities and pollution abatement devices adequate to ensure a quality of lake water necessary to achieve established water use objectives.

Sanitary Sewerage System Planning and Regional Water Quality Management Objectives

The four specific regional sanitary sewerage system development objectives already adopted by the Commission under its sanitary sewerage system plan are directly applicable to regional water quality management planning. Because the regional water quality management planning program described in this report is somewhat broader in scope, however, addressing both point and diffuse sources of pollution, these four objectives have been expanded and are hereby recommended, along with one additional objective, for adoption as the objectives applicable to the development of the regional water quality management plan. These are:

1. The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated need for sanitary and industrial wastewater disposal and the need for storm water runoff control generated by the existing and proposed land uses.

2. The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—so as to meet the recommended water use objectives and supporting water quality standards.

3. The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—that are properly related to and will enhance the overall quality of the natural and man-made environments.

4. The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—that are both economical and efficient, meeting all other objectives at the lowest cost possible.

5. The development of water quality management systems—inclusive of the governmental units and their responsibilities, authorities, policies, procedures, and resources—and supporting revenue-raising mechanisms which are effective and locally acceptable, and which will provide a sound institutional basis for plan implementation including the planning, design, construction, operation, maintenance, repair, and replacement of water quality control practices and facilities, inclusive of sanitary sewerage systems, storm water management systems, and land management practices.

Wastewater Sludge Management Systems Development Objectives

All six specific regional wastewater sludge management system development objectives are hereby recommended for inclusion as regional water quality management planning objectives. These are:

1. The development of a regional wastewater sludge management system which will effectively support the existing regional development pattern and serve to aid in the implementation of the regional land use plan while meeting the anticipated wastewater sludge handling and disposal needs generated by the existing and proposed land uses.

2. The development of a regional wastewater sludge management system which will meet established air and water use objectives and supporting standards; which will not result in pollution of the land rendering it unfit for desirable uses; and which will be properly related to the natural resource base and enhance the overall quality of the environment in the Region.

3. The development of a regional wastewater sludge management system which will effectively protect the public health within the Region.

4. The development of a regional wastewater sludge management system which will help to maintain the productivity of agricultural land.

5. The development of a regional wastewater sludge management system which will maximize the recovery and utilization of resources in the handling and disposal of wastewater sludges.

6. The development of a regional wastewater sludge management system which is both economical and efficient, meeting all other objectives at the lowest cost possible.

Principles and Standards

Complementing each of the foregoing specific water quality management objectives is a planning principle and a set of planning standards. These, as they apply to the five water quality management planning and development objectives recommended for adoption, are set forth in Table 1. These principles and standards facilitate quantitative application of the objectives in plan design, test, and evaluation. It should be noted that the planning standards herein recommended fall into two groups: comparative and absolute. The comparative standards, by their very nature, can be applied only through a comparison of alternative plan proposals. Absolute standards can be applied individually to each alternative plan proposal since they are expressed in terms of maximum, minimum, or desirable values. The standards should not

Table 1

WATER QUALITY MANAGEMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

OBJECTIVE NO. 1

The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—which will effectively serve the existing regional urban development pattern and promote implementation of the regional land use plan, meeting the anticipated need for sanitary and industrial wastewater disposal and the need for storm water runoff control generated by the existing and proposed land uses.

PRINCIPLE

Sanitary sewerage and storm water drainage systems are essential to the development and maintenance of a safe, healthy, and attractive urban environment. The extension of existing sanitary sewerage and storm water drainage systems and the creation of new systems can be effectively used to guide and shape urban development both spatially and temporally.

STANDARDS

1. Sanitary sewer service should be provided to all existing areas of medium-[a] or high-density[b] urban development and to all areas proposed for such development in the regional land use plan.

2. Sanitary sewer service should be provided to all existing areas of low-density[c] urban development and to all areas proposed for such development in the regional land use plan where such areas are contiguous to areas of medium- or high-density urban development. Where noncontiguous low-density development already exists, the provision of sanitary sewer service should be contingent upon the inability of the underlying soil resource base to properly support onsite absorption waste disposal systems.

3. Engineered and partially engineered storm water management facilities[d] should be provided to all existing areas of low-, medium-, and high-density urban development and to all areas proposed for such development in the regional land use plan.

4. Where public health authorities declare that public health hazards exist because of the inability of the soil resource base to properly support onsite soil absorption waste disposal systems, sanitary sewer service should be provided.

5. Lands designated as primary environmental corridors on the regional land use plan should not be served by sanitary sewers except that development incidental to the preservation and protection of the corridors, such as parks and related outdoor recreation areas, and existing clusters of urban development in such corridors. Engineering analyses relating to the sizing of sanitary sewerage facilities and storm water management facilities should assume the permanent preservation of all undeveloped primary environmental corridor lands in natural open space uses.

6. Floodlands[e] should not be served by sanitary sewers except that development incidental to the preservation in open space uses of floodlands, such as parks and related outdoor recreation areas, and existing urban development in floodlands not recommended for eventual removal in comprehensive plans. Engineering analyses relating to the sizing of sanitary sewerage or storm water management facilities should not assume ultimate development of floodlands for urban use.

7. Significant concentrations[f] of lands covered by soils found in the regional soil survey to have very severe limitations for urban development even with the provision of sanitary sewer service should not be provided with such service. Engineering analyses relating to the sizing of sewerage or storm water management facilities should not assume ultimate urban development of such lands for urban use.

8. The timing of the extension of sanitary sewerage facilities should, insofar as possible, seek to promote urban development in a series of complete neighborhood units, with service being withheld from any new units in a given municipal sewer service area until previously served units are substantially developed and until existing units not now served are provided with service.

9. The sizing of sanitary sewerage and storm water management facility components should be based upon an assumption that future land use development will occur in general accordance with the adopted regional land use plan.

10. To the extent feasible, industrial wastes except clear cooling waters, as well as the sanitary wastes generated at industrial plants, should be discharged to municipal sanitary sewerage systems for ultimate treatment and disposal. The necessity to provide pretreatment for industrial wastes should be determined on an individual case-by-case basis and should consider any regulations relating thereto.

11. Rural land management practices will be given priority in areas which are designated as prime agricultural lands to be preserved in long-term use for the production of food and fiber.

Table 1 (continued)

## OBJECTIVE NO. 2

The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—so as to meet the recommended water use objectives and supporting water quality standards as set forth on Map 1 and Table 2.

## PRINCIPLE

Sewage treatment plant effluent, industrial wastewater discharges, and rural and urban runoff are major contributors of pollutants to the streams and lakes of the Region; the location, design, construction, operation, and maintenance of sewage treatment plants, industrial wastewater outfalls, and storm water management facilities and the quality and quantity of the wastewater from such facilities has a major effect on stream and lake water quality and the ability of that water to support the established water uses.

## STANDARDS

1. The level of treatment to be provided at each sewage treatment plant and industrial wastewater outfall should be determined by water quality analyses directly related to the established water use objectives for the receiving surface water body. These analyses should demonstrate that the proposed treatment level will aid in achieving the water quality standards supporting each major water use objective as set forth on Map 1 and Table 2.

2. The type and extent of storm water treatment or associated preventive land management practices to be applied within a hydrologic unit should be determined by water quality analyses directly related to the established water use objectives for the receiving surface water body. These analyses should demonstrate that the proposed treatment level or land management practices will aid in achieving the water quality standards supporting each major water use objective as set forth on Map 1 and Table 2.

3. Domestic livestock should be fenced out of all lakes and perennial streams, and direct storm water runoff from the associated feeding areas to the lakes and perennial streams should be avoided so as to contribute to the achievement of the established water use objectives and standards.

4. The discharge of sewage treatment plant effluent directly to inland lakes should be avoided and sewage treatment plant discharges to streams flowing into inland lakes should be located and treated so as to contribute to the achievement of the established water use objectives and standards for those lakes.

5. The specific standards for sewage treatment at all sewage treatment plants discharging effluent to Lake Michigan shall be those established by the Federal Lake Michigan Enforcement Conference, or the amendments established thereto as a result of other subsequent federal administrative and enforcement actions.

6. Existing sewage treatment plants scheduled to be abandoned within the plan design period should provide only secondary waste treatment and disinfection of effluent unless a further degree of treatment is determined to be required to meet the established water use objectives and standards for the receiving surface water body.

7. Interim sewage treatment plants deemed necessary to be constructed prior to implementation of the long-range plan should provide levels of treatment determined by water quality analyses directly related to the established water use objectives and standards for the receiving surface water body.

8. Bypassing of sewage to storm sewer systems, open channel drainage courses, and streams should be prohibited.

9. Combined sewer overflows should be eliminated or adequately treated to meet the established water use objectives and standards for the receiving body of surface water.

10. Sewage treatment plants should be designed to perform their intended function and to provide their specified level of treatment under adverse conditions of inflow, should be of modular design with sufficient standby capacity to allow maintenance to be performed without bypassing influent sewage, and should not be designed to bypass any flow delivered by the inflowing sewers, but should incorporate an emergency bypass facility sufficient to protect sewage treatment equipment against flows in excess of the design hydraulic capacity of the plant.

11. All industrial sewage treatment plants should, by 1983, provide the best available wastewater treatment which is economically achievable.

12. All sanitary sewage treatment plants should, by 1983, provide the best practicable wastewater treatment technology.

13. By 1985, no pollutants should be discharged by sanitary or industrial sewage treatment plants in amounts which would preclude the achievement of the recommended water use objectives or the supporting standards as set forth on Map 1 and Table 2.

14. The orderly transition of lands from open space, agricultural, or other rural uses to urban uses through excavation, landshaping, and construction should be planned, designed, and conducted so as to contribute to the achievement of the established water use objectives and standards.

Table 1 (continued)

## OBJECTIVE NO. 3

The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—that are properly related to and will enhance the overall quality of the natural and man-made environments.

## PRINCIPLE

The improper design, installation, application, or maintenance of land management practices, sanitary sewerage system components, and storm water management components can adversely affect the natural and man-made environments; therefore, every effort should be made in such actions to properly relate to these environments and minimize any disruption or harm thereto.

## STANDARDS

1. New and replacement sewage treatment plants, as well as additions to existing plants, should, wherever possible, be located on sites lying outside of the 100-year recurrence interval floodplain. When it is necessary to use floodplain lands for sewage treatment plants, the facilities should be located outside of the floodway so as to not increase the 100-year recurrence interval flood stage, and should be floodproofed to a flood protection elevation of two feet above the 100-year recurrence interval flood stage so as to assure adequate protection against flood damage and avoid disruption of treatment and consequent bypassing of sewage during flood periods. In the event that a floodway has not been established, or if it is necessary to encroach upon an approved floodway, the hydraulic effect of such encroachment should be evaluated on the basis of an equal degree of encroachment for a significant reach on both sides of the stream, and the degree of encroachment should be limited so as not to raise the peak stage of the 100-year recurrence interval flood by more than 0.1 foot.

2. Existing sewage treatment plants located in the 100-year recurrence interval floodplain should be floodproofed to a flood protection elevation of two feet above the 100-year recurrence interval flood stage so as to assure adequate protection against flood damage and avoid disruption of treatment and consequent bypassing of sewage during flood periods.

3. The location of new and replacement of old sewage treatment plants or storm water storage and treatment facilities should be properly related to the existing and proposed future urban development pattern as reflected in the regional land use plan and to any community or neighborhood unit development plans prepared pursuant to, and consistent with, the regional land use plan.

4. New and replacement sewage treatment plants, as well as additions to existing plants, should be located on sites large enough to provide for adequate open space between the plant and existing or planned future urban land uses; should provide adequate area for expansion to ultimate capacity as determined in the regional sanitary sewerage system plan; and should be located, oriented, and architecturally designed so as to complement their environs and to present an attractive appearance consistent with their status as public works.

5. The disposal of sludge from sewage treatment plants should be accomplished in the most efficient manner possible, consistent, however, with any adopted rules and regulations pertaining to air quality control and solid waste disposal.

6. Devices used for long-term or short-term storage of pollutants which are collected through treatment of wastewater or through the application of land management practices should, wherever possible, be located on sites lying outside of the 100-year recurrence interval floodplain. When it is necessary to use floodplain lands for such facilities, such devices should be located outside of the floodway so as not to increase the 100-year recurrence interval flood stage, and should be floodproofed to a flood protection elevation of two feet above the 100-year recurrence interval flood stage so as to assure adequate protection against flood damage and to avoid redispersal of the pollutants into natural waters during flood periods. In the event that a floodway has not been established, or if it is necessary to encroach upon an approved floodway, the hydraulic effect of such encroachment shall be evaluated on the basis of an equal degree of encroachment for a significant reach on both sides of the stream and the degree of encroachment shall be limited so as not to raise the peak stage of the 100-year recurrence interval flood by more than 0.1 foot. This standard is not intended to preclude the construction of storm water detention-retention facilities, such as small-scale cascade basins in series along a stream channel, which by their design require emplacement within a floodway or floodplain. In these cases, the effects on water quality and upstream flood stages must be considered explicitly.

7. There should be no discharge of heavy metals, pesticides, industrial chemicals, or other substances in quantities known to be toxic or hazardous to fish or other aquatic life.

8. Water quality should not be degraded beyond existing levels except where a demonstration of economic hardship or compelling social need is presented.

## OBJECTIVE NO. 4

The development of land management and water quality control practices and facilities—inclusive of sanitary sewerage systems—that are economical and efficient, meeting all other objectives at the lowest possible cost.

Table 1 (continued)

## PRINCIPLE

The total resources of the Region are limited and any undue investment in water pollution control systems must occur at the expense of other public and private investment; total pollution abatement costs, therefore, should be minimized while meeting and achieving all water quality standards and objectives.

## STANDARDS

1. The sum of sanitary sewerage system operating and capital investment costs should be minimized.

2. The sum of storm water control facility and related land management practice operating and capital investment costs should be minimized.

3. The total number of sanitary sewerage systems and sewage treatment facilities should be minimized in order to effect economies of scale and concentrate responsibility for water quality management. Where physical consolidation of sanitary sewer systems is uneconomical, administrative and operational consolidation should be considered in order to obtain economy in manpower utilization and to minimize duplication of administrative, laboratory, storage, and other necessary services, facilities, and equipment. The total number of diffuse pollution control facilities should be minimized in order to concentrate the responsibility for water quality management.

4. Maximum feasible use should be made of all existing and committed pollution control facilities, which should be supplemented with additional facilities only as necessary to serve the anticipated wastewater management needs generated by substantial implementation of the regional land use plan, while meeting pertinent water quality use objectives and standards.

5. The use of new or improved materials and management practices should be allowed and encouraged if such materials and practices offer economies in materials or construction costs or by their superior performance lead to the achievement of water quality objectives at a lesser cost.

6. Sanitary sewerage systems, sewage treatment plants, and storm water management facilities should be designed for staged or incremental construction where feasible and economical so as to limit total investment in such facilities and to permit maximum flexibility to accommodate changes in the rate of population growth and the rate of economic activity growth, changes in water use objectives and standards, or changes in the technology for wastewater management.

7. When technically feasible and otherwise acceptable, alignments for new sewer construction should coincide with existing public rights-of-way in order to minimize land acquisition or easement costs and disruption to the natural resource base.

8. Clear water inflows to the sanitary sewerage system should be eliminated and infiltration should be minimized.

9. Sanitary sewerage systems and storm water management systems should be designed and developed concurrently to effect engineering and construction economies as well as to assure the separate function and integrity of each of the two systems; to immediately achieve the pollution abatement and drainage benefits of the integrated design; and to minimize disruption of the natural resource base and existing urban development.

## OBJECTIVE NO. 5

The development of water quality management institutions—inclusive of the governmental units and their responsibilities, authorities, policies, procedures, and resources—and supporting revenue-raising mechanisms which are effective and locally acceptable, and which will provide a sound basis for plan implementation including the planning, design, construction, operation, maintenance, repair, and replacement of water quality control practices and facilities, inclusive of sanitary sewerage systems, storm water management systems, and land management practices.

## PRINCIPLE

The activities necessary for the achievement of the established water use objectives and supporting standards are expensive; technically, adminstratively, and legally complex; and important to the economic and social well being of the residents of the Region. Such activities require a continuing, long-term commitment and attention from public and private entities. The conduct of such activities requires that the groups designated as responsible for plan implementation have sufficient financial and technical capabilities, legal authorities, and general public support to accomplish the specific tasks identified.

Table 1 (continued)

**STANDARDS**

1. Each designated management agency should develop and establish a system of user charges and industrial cost recovery to maintain accounts to support the necessary operation, maintenance, and replacement expenditures.

2. Maximum utilization should be made of existing institutional structures in order to minimize the number of agencies designated to implement the recommended water quality control measures, and the creation of new institutions should be recommended only where necessary.

3. To the greatest extent possible, the responsibility for water pollution control and abatement should be assigned to the most immediate local public agency or to the most directly involved private entity.

4. Each designated management group should have legal authority, financial resources, technical capability, and practical autonomy sufficient to assure the timely accomplishment of its responsibilities in the achievement of the recommended water use objectives and supporting standards as set forth on Map 1 and Table 2.

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[a] *Medium-density development is defined as that development having an average dwelling unit density of 4.4 dwelling units per net residential acre, and a net lot area per dwelling unit ranging from 6,231 to 18,980 square feet.*

[b] *High-density development is defined as that development having an average dwelling unit density of 12.0 dwelling units per net residential acre and a net lot area per dwelling unit ranging from 2,439 to 6,230 square feet.*

[c] *Low-density development is defined as that development having an average dwelling unit density of 1.2 dwelling units per net residential acre and a net lot area per dwelling unit ranging from 18,981 to 62,680 square feet.*

[d] *Engineered storm water management facilities are defined here as the systems or subsystems of storm water catchment, conveyance, storage, and treatment facilities comprised of structural controls including natural and man-made surface drains, subsurface piped drains, or combinations thereof, and of pumping stations, surface or subsurface storage or detention basins, and other appurtenances associated therewith, and sized to accommodate estimated flows or quantities from the tributary drainage area as a result of a specified meteorologic or hydrologic event.*

[e] *Floodlands are defined as those lands, including floodplains, floodways, and channels, subject to inundation by the one hundred (100)-year recurrence interval flood or, where such data are not available, the maximum flood of record.*

[f] *Areas larger than 160 acres in extent.*

*Source: SEWRPC.*

only aid in the development, test, and evaluation of plan implementation measures, but should serve as an aid to local government in water quality-related decisions.

Specific Recommended Water Use Objectives and Supporting Water Quality Standards

In Volume One of this report the current water use objectives adopted by the Wisconsin Natural Resources Board and set forth in Chapters NR 102 through NR 105 of the Wisconsin Administrative Code were discussed and interpreted with respect to their application to the surface waters of the Region. Eight individual water use objectives were identified as being currently applied throughout Wisconsin, either singly or in combinations. These eight water use objectives are: recreation, public water supply, warmwater fishery and aquatic life, trout fishery and aquatic life, salmon spawning fishery and aquatic life, limited fishery (intermediate aquatic life), restricted recreational use, and marginal use. In addition, a ninth objective termed "minimum" and dealing primarily with the control of the aesthetic aspects of water pollution is applied to all surface waters of the State.

In Public Law 92-500 enacted in 1972, the U. S. Congress set as a national goal to be achieved by July 1, 1983 water quality which provides for the protection and propogation of fish, shellfish, and wildlife, and which provides for recreation in and on the water. The PL 92-500 goals are frequently referred to as "fishable and swimmable" waters. Congress recognized that, as a practical matter, more limited use objectives may have to be established for some streams and lakes after consideration by the states of the practical potential of streams and lakes for public water supply, propagation of fish and wildlife, recreation, agriculture, industry, and navigation. Of the above-mentioned specific water use objectives currently in use in Wisconsin, those objectives termed recreation, public water supply, warmwater fishery and aquatic life, trout fishery and aquatic life, and salmon spawning fishery and aquatic life all directly relate to and are fully compatible with the national goal of "fishable and swimmable" waters. The limited fishery (intermediate aquatic life), restricted recreational use, marginal use, and minimum use objectives all envision levels of water quality that will not be fully "fishable and swimmable."

In conducting the regional water quality management planning program for southeastern Wisconsin, an attempt was made to first assign to all surface waters in the Region an appropriate combination of those use objectives which would fully meet the 1983 national goal of "fishable and swimmable" waters. This assignment differed significantly from the water use objectives currently in effect within southeastern Wisconsin for which many miles of surface streams have been assigned more limited use objectives. An analysis was made of the potential of each stream reach and of each major lake to meet objectives consistent with the national goal of "fishable and swimmable" waters. This analysis took into account the results of inventories of stream and lake physical characteristics and conditions, existing water quality, sources of pollution in tributary drainage areas, character of land uses in tributary drainage areas, and location and extent of in-place pollutants. One of the planning tools used in the analysis was the hydrologic-hydraulic-water quality simulation model, which served to synthesize much of the inventory and forecast data. This analysis, which is discussed in Chapter IV of this volume and which was applied to a total of 1,180 stream miles and to the 100 major lakes in the Region, indicated that for reasons relating to natural conditions, to gross levels of in-place pollutants, or to essentially irreversible man-made improvements such as concrete channelization, it would not be practicable to meet the national goal of "fishable and swimmable" waters for all surface waters in the Region. However, the analysis also indicated that it would be possible to significantly upgrade the current water use objectives so that many more miles of streams could either fully meet the national goal, or meet a goal more stringent than the restricted and minimum use categories.

The results of the analysis of the water use objectives for the surface waters of the Region are graphically summarized on Map 1, which sets forth the Commission-recommended water use objectives for streams and lakes within the Region. The following five combinations of water use objectives have been recognized in the application of such objectives to the 1,180 mile-stream network and the 100 major lakes in the Region:

1. Salmon spawning fishery and aquatic life, recreational use, and minimum standards

2. Trout fishery and aquatic life, recreational use, and minimum standards

3. Warmwater fishery and aquatic life, recreational use, and minimum standards

4. Warmwater fishery and aquatic life, limited recreational use, and minimum standards

5. Limited fishery and aquatic life, limited recreational use, and minimum standards

Of the five water use objective combinations, only the first three, providing for a full warmwater fishery and full body contact recreational use, are fully compatible with the national goal of "fishable and swimmable" waters. Of the 1,180 stream miles analyzed in the program, 1,054 miles, or 89 percent, fall into one of these three categories, including 27 miles, or 2 percent, in the trout fishery and recreational use category, and 1,027 miles, or 87 percent, in the warmwater fishery and recreational use category. The salmon spawning fishery and recreational use category applies only to portions of the Lake Michigan estuaries of five streams. The 1,180-mile stream network identified above does not include the Lake Michigan estuary portions of any of the regional streams that drain to Lake Michigan. The remaining 126 stream miles, or about 11 percent, would not meet the national goal of "fishable and swimmable" waters. These stream miles generally either have excessive nutrient levels which cannot as a practical matter be sufficiently reduced or lie within the intensely urbanized portion of the Region and have been significantly and permanently altered through concrete channelization. Of these 126 stream miles, 56 miles, or 5 percent, have been placed within the warmwater fishery and limited recreational use category, and 70 miles, or 6 percent, have been placed in the limited fishery and limited recreational use category. Significantly, the restricted use category is not recommended to be applied within the Region in future years, since the analysis indicated that at least a limited fishery and partial body contact recreational use, such as wading and boating, can be achieved for all streams in the Region.

Of the 100 major lakes in the Region, 95 lakes fall into water use objective categories that are deemed to be fully compatible with the national goal of "fishable and swimmable" waters. Of these 95 lakes, one—Lake Geneva—has been placed in the trout fishery and recreational use category, and 94 have been placed in the warmwater

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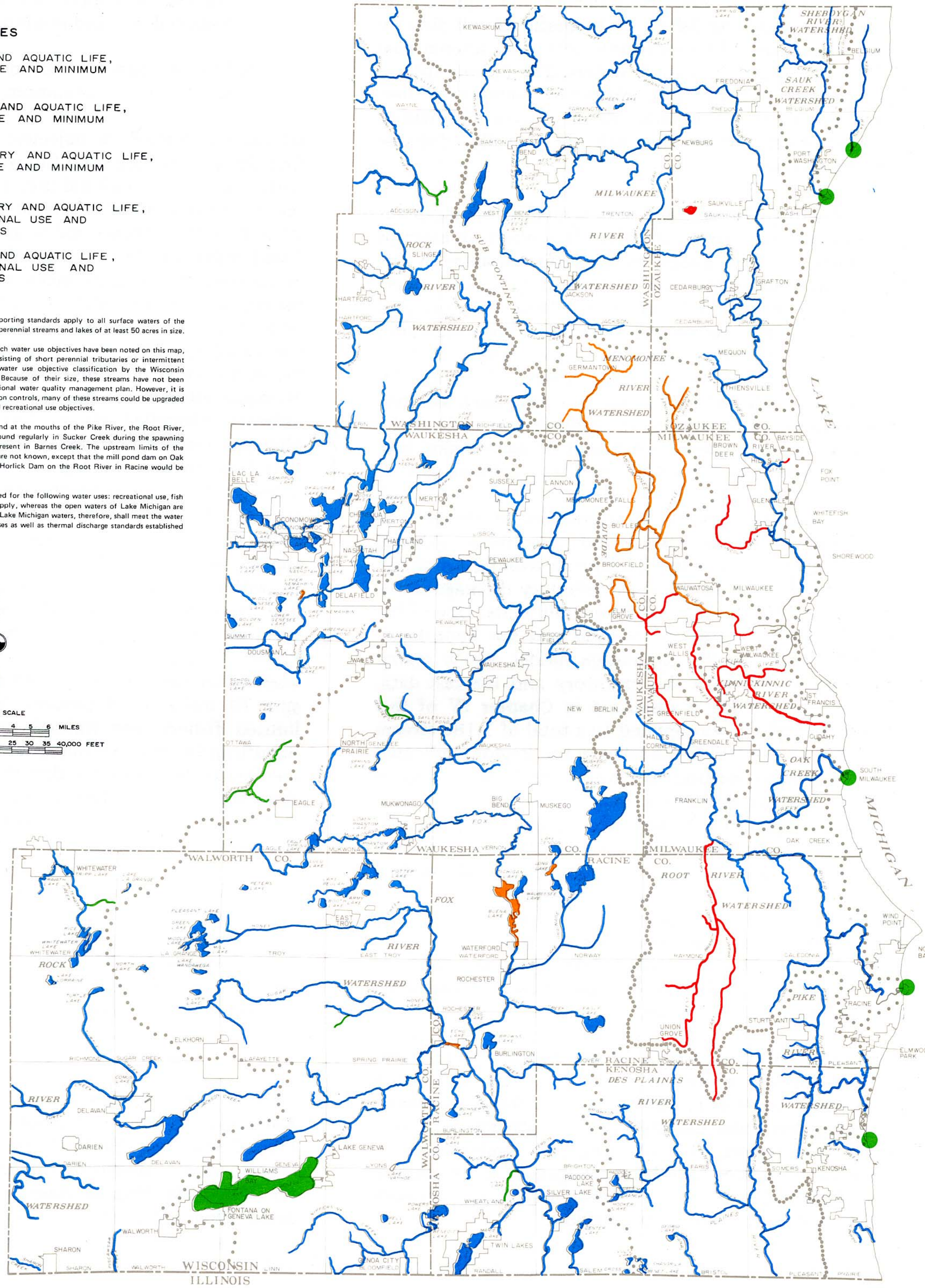
[2] *The estuary reaches of the Milwaukee, Menomonee, Kinnickinnic, Pike, and Root Rivers and of Oak Creek, Pike Creek, and Sauk Creek total about 15 miles in length. Where identified on Map 1 and as adopted by the Wisconsin Natural Resources Board, the water use designation for portions of five estuary reaches is for salmon spawning fishery and recreational use. No specific water use objectives for the remaining estuary reaches were assigned under the areawide water quality management planning program. Because of the complexity of the estuaries, it is envisioned that supplemental estuary studies will have to be undertaken to fully assess the water quality related problems of these estuaries and to intelligently assign appropriate water use objectives to all the estuaries.*

## Map 1

### RECOMMENDED WATER USE OBJECTIVES FOR LAKES AND STREAMS IN SOUTHEASTERN WISCONSIN: 2000




NOTES:

1. These water use objectives and supporting standards apply to all surface waters of the Region. This map only shows major perennial streams and lakes of at least 50 acres in size.
2. In addition to those streams for which water use objectives have been noted on this map, there are other stream reaches consisting of short perennial tributaries or intermittent streams which have been given a water use objective classification by the Wisconsin Department of Natural Resources. Because of their size, these streams have not been specifically addressed under the regional water quality management plan. However, it is expected that given adequate pollution controls, many of these streams could be upgraded to achieve the warmwater fishery and recreational use objectives.
3. Salmon are released in Oak Creek and at the mouths of the Pike River, the Root River, and Sauk Creek. Salmon are also found regularly in Sucker Creek during the spawning periods and could potentially be present in Barnes Creek. The upstream limits of the existing spawning runs in the creeks are not known, except that the mill pond dam on Oak Creek in South Milwaukee and the Horlick Dam on the Root River in Racine would be impassable to the fish.
4. All Lake Michigan waters are intended for the following water uses: recreational use, fish and aquatic life, and public water supply, whereas the open waters of Lake Michigan are intended to support a trout fishery. Lake Michigan waters, therefore, shall meet the water quality standards supporting these uses as well as thermal discharge standards established especially for Lake Michigan.

Under the regional water quality management planning program, analyses were conducted to determine the feasibility of achieving a level of water quality that would make all surface waters "fishable and swimmable" as envisioned by the U. S. Congress in Public Law 92-500. The results of these analyses indicated that of the 1,180 stream miles analyzed, about 1,054 or 89 percent, could be brought to "fishable and swimmable" standards, thereby meeting the Congressional goal. The remaining 126 miles, or 11 percent, would not be able to meet the goal because of excessive nutrient levels which cannot as a practical matter be sufficiently reduced or because of the significant and irreversible alteration of the stream channels through concrete lining. Of the 100 major lakes in the Region, 95 could meet the national goal of "fishable and swimmable" waters. The remaining 5 could not meet this goal, primarily because of excessive nutrient loadings which cannot as a practical matter be sufficiently reduced, or natural conditions which preclude the satisfaction of "fishable and swimmable" standards.

*Source: SEWRPC.*

fishery and recreational use category. Of the remaining 5 major lakes in the Region, one—Mud Lake in Ozaukee County—has been placed in the limited fishery and aquatic life and limited recreational use category because of the natural bog conditions which preclude most recreational uses and the maintenance of a warmwater fishery. The remaining 4 lakes have been placed in the warmwater fishery and limited recreational use category because of estimated excessive nutrient loadings to the lakes which cannot as a practical matter be sufficiently reduced, resulting in accelerating rates of lake fertilization and attendant aquatic plant growth.

The specific water quality standards supporting each of the recommended water use objectives are documented in Table 2. The specific changes from the existing state-adopted water use objectives are individually documented in Table 3. Finally, Table 4 documents the recommended changes between the water use objectives as identified in the previous Commission plan elements and the new recommended water use objectives.

## SUMMARY

The task of formulating objectives and standards to be used in plan design and evaluation is a difficult but necessary part of the planning process. It is readily conceded that regional plan elements must advance proposals which are physically feasible, economically sound, aesthetically pleasing, and conducive to the promotion of public health and safety. The agreement of objectives beyond such generalities, however, becomes more difficult to achieve because the definition of specific development objectives and supporting standards inevitably involves value judgements. Nevertheless, it is essential to formulate such objectives for the management of water quality, and to quantify them insofar as possible through standards in order to provide the framework through which the regional water quality management plan can be prepared. Moreover, so that the plan will form an integral part of the overall framework of long-range plans for the physical development of the Region, the water quality management objectives must be compatible with, and dependent upon, other regional development objectives. Therefore, the regional water quality management objectives and supporting principles and standards as set forth in this chapter are based upon previously adopted regional development objectives, supplementing these only as required to meet the specific needs of the regional water quality management planning program.

Five development objectives, together with supporting principles and standards, were formulated under the regional water quality management planning program. Four of these were expansions of objectives previously adopted under the Commission's regional sanitary sewerage system plan, broadened to incorporate concepts pertinent to the areawide water quality management planning program. Together with the land use, related water control facility, and wastewater sludge management system development objectives established under related Commission work programs, these objectives, principles, and standards provided the basic framework within which alternative regional water quality management plans were formulated and a recommended areawide water quality management plan synthesized.

## Table 2

## RECOMMENDED WATER USE OBJECTIVES AND WATER QUALITY STANDARDS FOR LAKES AND STREAMS IN THE SOUTHEASTERN WISCONSIN REGION: 2000[a]

| Water Quality Parameters | Individual Water Use Objectives[b] Applicable to Southeastern Wisconsin Inland Lakes and Streams | | | | | | | | Combinations of Water Use Objectives Applicable to Southeastern Wisconsin Inland Lakes and Streams | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Recreational Use | Limited Recreational Use | Public Water Supply | Warmwater Fishery | Trout Fishery | Salmon Spawning Fishery | Limited Fishery | Minimum Standards[c] | Limited Fishery and Aquatic Life, Limited Recreational Use, and Minimum Standards[c] | Warmwater Fishery and Aquatic Life, Limited Recreational Use, and Minimum Standards[c] | Warmwater Fishery and Aquatic Life, Recreational Use, and Minimum Standards[c] | Trout Fishery and Aquatic Life, Recreational Use, and Minimum Standards[c] | Salmon Spawning Fishery and Aquatic Life, Recreational Use, and Minimum Standards[c] |
| Maximum Temperature ($^{\circ}$F) | -- | -- | -- | 89[d,g] | --[d,e,g] | --[d,e,g] | 89[d,g] | -- | 89[d,g] | 89[d,g] | 89[d,g] | --[d,e,g] | --[d,e,g] |
| pH Range (S.U.) | -- | -- | 6.0-9.0[f] | 6.0-9.0[f] | 6.0-9.0[f] | 6.0-9.0[f] | 6.0-9.0[f] | -- | 6.0-9.0[f] | 6.0-9.0[f] | 6.0-9.0[f] | 6.0-9.0[f] | 6.0-9.0[f] |
| Minimum Dissolved Oxygen (mg/l) | 2.0 | 2.0 | -- | 5.0[g] | 6.0[g,h] | 5.0[g,i] | 3.0[g] | -- | 3.0[g] | 5.0[g] | 5.0[g] | 6.0[g,h] | 5.0[g,i] |
| Maximum Fecal Coliform (Counts per 100 ml) | 200-400[j] | 200-400[j] | 200-400[j] | -- | -- | -- | -- | -- | 200-400[j] | 200-400[j] | 200-400[j] | 200-400[j] | 200-400[j] |
| Maximum Total Residual Chlorine (mg/l) | -- | -- | -- | 0.01 | 0.002 | 0.002 | 0.5 | -- | 0.5 | 0.01 | 0.01 | 0.002 | 0.002 |
| Maximum Un-ionized Ammonia Nitrogen (mg/l) | -- | -- | -- | 0.02[r] | 0.02[r] | 0.02[r] | 0.2[s] | -- | 0.2[s] | 0.02[r] | 0.02[r] | 0.02[r] | 0.02[r] |
| Maximum Total Phosphorus[k] (mg/l) | | | | | | | | | | | | | |
| Streams | 0.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.1 | 0.1 | 0.1 |
| Lakes | 0.02 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 0.02 | 0.02 | -- |
| Maximum Total Dissolved Solids (mg/l) | -- | -- | 500-750[l] | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Other[p,q] | -- | -- | --[m] | --[o] | --[n] | --[o] | --[o] | -- | --[o] | --[o] | --[o] | --[n,o] | --[o] |

[a] *Includes SEWRPC interpretations of all basic water use categories established by the Wisconsin Department of Natural Resources and additional categories established under the areawide water quality management planning program, plus those combinations of water use categories applicable to the Southeastern Wisconsin Region. It is recognized that under both extremely high and extremely low flow conditions, instream water quality levels can be expected to violate the established water quality standards for short periods of time without damaging the overall health of the stream. It is important to note the critical differences between the official state and federally adopted water quality standards—composed of "use designations" and "water quality criteria"—and the water use objectives and supporting standards of the Regional Planning Commission described here. The U. S. Environmental Protection Agency and the Wisconsin Department of Natural Resources, being regulatory agencies, utilize water quality standards as a basis for enforcement actions and compliance monitoring. This requires that the standards have a rigid basis in research findings and in field experience. The Commission, by contrast, must forecast regulations and technology far into the future, documenting the assumptions used to analyze conditions and problems which may not currently exist anywhere, much less in or near southeastern Wisconsin. As a result, more recent—and sometimes more controversial—study findings must sometimes be applied. This results from the Commission's use of the water quality standards as criteria to measure the relative merits of alternative plans.*

[b] *Standards presented in the table are applicable to lakes larger than 50 acres in surface area and to major streams of the Region as set forth in Map 1.*

[c] *All waters shall meet the following minimum standards at all times and under all flow conditions: substances that will cause objectionable deposits on the shore or in the bed of a body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts found to be of public health significance, nor shall substances be present in amounts which are acutely harmful to animal, plant, or aquatic life.*

[d] *There shall be no temperature changes that may adversely affect aquatic life. Natural daily and seasonal temperature fluctuations shall be maintained. The maximum temperature rise at the edge of the mixing zone above the existing natural temperature shall not exceed $5^{\circ}$F for streams and $3^{\circ}$F for lakes.*

[e] *There shall be no significant artificial increases in temperature where natural trout or stocked salmon reproduction is to be protected.*

[f] *The pH shall be within the range of 6.0 to 9.0 standard units with no change greater than 0.5 unit outside the estimated natural seasonal maximum and minimum.*

[g] *Dissolved oxygen and temperature standards apply to streams and the epilimnion of stratified lakes and to the unstratified lakes; the dissolved oxygen standard does not apply to the hypolimnion of stratified inlake lakes. Trends in the period of anaerobic conditions in the hypolimnion of stratified inland lakes should be considered important to the maintenance of water quality, however.*

[h] *Dissolved oxygen shall not be lowered to less than 7.0 mg/l during the trout spawning season.*

[i] *The dissolved oxygen in the Great Lakes tributaries used by stock salmonids for spawning runs shall not be lowered below natural background during the period of habitation.*

[j] *Shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month nor a monthly geometric mean of 400 per 100 ml in more than 10 percent of all samples during any month.*

[k] *The values presented for lakes are the critical total phosphorus concentrations which apply only during spring when maximum mixing is underway. In streams classified for recreational use, the total phosphorus concentration shall not exceed 0.1 mg/l. A phosphorus standard does not apply to streams and lakes classified for limited recreational use.*

[l] *Not to exceed 500 mg/l as a monthly average nor 750 mg/l at any time.*

[m] *The intake water supply shall be such that by appropriate treatment and adequate safeguards it will meet the established Drinking Water Standards.*

[n] *Streams classified as trout waters shall not be altered from natural background by effluents that influence the stream environment to such an extent that trout populations are adversely affected.*

[o] *Unauthorized concentrations of substances are not permitted that alone or in combination with other materials present are toxic to fish or other aquatic life. The determination of the toxicity of a substance shall be based upon the available scientific data base. References to be used in determining the toxicity of a substance shall include, but not be limited to, Quality Criteria for Water. EPA-440/9-76-003, U. S. Environmental Protection Agency, Washington, D.C., 1976, and Water Quality Criteria 1972. EPA-R3-73-003, National Academy of Sciences, National Academy of Engineering, U. S. Government Printing Office, Washington, D.C., 1974. Questions concerning the permissible levels, or changes in the same, of a substance, or combination of substances, or undefined toxicity to fish and other biota shall be resolved in accordance with the methods specified in Water Quality Criteria 1972 and Standard Methods for the Examination of Water and Wastewater, 14th Edition, American Public Health Association, New York, 1975, or other methods approved by the Department of Natural Resources.*

[p] *Waters important to overall environmental integrity including trout streams, scientific areas, wild and scenic areas, endangered species habitat, and waters of high recreational potential all are subject to further pollution analysis and special standards and effluent criteria. See Wisconsin Administrative Code Chapter NR 104.02(4)(a), whereby this is to be determined by the Wisconsin Department of Natural Resources on a case-by-case basis. No waters in southeastern Wisconsin are currently designated under this category as of 1977.*

[q] *Lake Michigan thermal discharge standards, which are intended to minimize the effects on aquatic biota, apply to facilities discharging heated water directly to Lake Michigan, excluding that from municipal waste and water treatment plants and vessels or ships. Such discharges shall not raise the temperature of Lake Michigan at the boundary of the mixing zone established by the Wisconsin Department of Natural Resources by more than $3^{\circ}$F and, except for the Milwaukee and Port Washington Harbors, thermal discharges shall not increase the temperature of Lake Michigan at the boundary of the established mixing zones during the following months above the following limits:*

| | | | |
|---|---|---|---|
| *January, February, March* | *$45^{\circ}$F* | *July, August, September* | *$80^{\circ}$F* |
| *April* | *$55^{\circ}$F* | *October* | *$65^{\circ}$F* |
| *May* | *$60^{\circ}$F* | *November* | *$60^{\circ}$F* |
| *June* | *$70^{\circ}$F* | *December* | *$50^{\circ}$F* |

*After a review of the ecological and environmental impact of thermal discharges in excess of a daily average of 500 million BTU per hour, mixing zones are established by the Department of Natural Resources. Any plant or facility, the construction of which is commenced on or after August 1, 1974, shall be so designed that the thermal discharges therefrom to Lake Michigan comply with mixing zones established by the Department. In establishing a mixing zone, the Department will consider ecological and environmental information obtained from studies conducted subsequent to February 1, 1974, and any requirements of the Federal Water Pollution Control Act Amendments of 1972, or regulations promulgated thereto.*

[r] *This level of un-ionized ammonia is assumed to be present at the temperature range of 70-$75^{\circ}$F and pH of 8.0 standard units, which are generally the critical conditions in the Region, and at ammonia-nitrogen concentrations of about 0.4 mg/l or greater, and has been recommended by the U. S. EPA as a water quality standard for the protection of fish and other aquatic life of the types found in the natural waters of the Region.*

[s] *This level of un-ionized ammonia is assumed to be present at the temperature range of 70-$75^{\circ}$F and pH of 8.0 standard units, which are generally the critical conditions in the Region, and at ammonia-nitrogen concentrations of about 3.5 mg/l or greater, and has been identified by the U. S. EPA as a maximum concentration for the protection of tolerant species of insect life and forage minnows and other aquatic life of the types found in the Region.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Table 3

COMPARISON OF 1976 WISCONSIN NATURAL RESOURCE BOARD-ADOPTED WATER USE OBJECTIVES TO THE SEWRPC-RECOMMENDED WATER USE OBJECTIVES

| Watershed | Stream Identification | Water Use Objectives as Adopted by the Wisconsin Natural Resources Board in 1976 | Water Use Objectives as Recommended by SEWRPC | Rationale for Change Recommended by SEWRPC |
|---|---|---|---|---|
| Des Plaines River | Salem branch from Hooker Lake to confluence with unnamed tributary in Sections 7 and 18, Town of Bristol | Limited fishery, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| Fox River | Unnamed tributary to a tributary of Sugar Creek flowing northeast through Sections 19 and 20, Town of Spring Prairie | Warmwater fishery and aquatic life, recreational use, and minimum standards | Trout fishery and aquatic life, recreational use, and minimum standards | Native trout populations are reproducing and are locally managed for a trout fishery |
| | Eagle Creek from Eagle Lake to CTH J | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of a higher water use objective |
| | Eagle Creek from CTH J to confluence with the Fox River | Limited fishery, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Genesee Creek upstream of the confluence with Spring Creek | Warmwater fishery and aquatic life, recreational use, and minimum standards | Trout fishery and aquatic life, recreational use, and minimum standards | Native trout populations are reproducing and are locally managed for a trout fishery |
| | Headwater area of Poplar Creek upstream of the Chicago & Northwestern Railroad Bridge | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Poplar Creek downstream of the Chicago & Northwestern Railroad Bridge | Limited fishery, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Deer Creek | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| Menomonee River | West branch, north branch, and main stem of Menomonee River from headwaters to confluence with Honey Creek | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Phosphorus levels cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth and provide for full recreational use |
| | Main Stem of Menomonee River from confluence with Honey Creek downstream to USH 41 (Stadium Freeway) | Restricted use and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective. |
| | Main stem of Menomonee River from USH 41 (Stadium Freeway) to Falk Corporation Dam | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |

Table 3 (continued)

| Watershed | Stream Identification | Water Use Objectives as Adopted by the Wisconsin Natural Resources Board in 1976 | Water Use Objectives as Recommended by SEWRPC | Rationale for Change Recommended by SEWRPC |
|---|---|---|---|---|
| Menomonee River (continued) | Little Menomonee River | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Phosphorus levels cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth and provide for full recreational use |
| | Little Menomonee Creek | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Phosphorus levels cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth and provide for full recreational use |
| | Butler Ditch | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Phosphorus levels cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth and provide for full recreational use |
| | Underwood Creek upstream of Watertown Plank Road | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Phosphorus levels cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth and provide for full recreational use |
| | Underwood Creek downstream of Watertown Plank Road | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Lilly Creek | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Phosphorus levels cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth and provide for full recreational use |
| | Honey Creek | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| Milwaukee River | Lincoln Creek from headwaters to Green Bay Road | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Lincoln Creek downstream of Green Bay Road | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Indian Creek upstream of IH 43 | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Indian Creek downstream of IH 43 | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |

Table 3 (continued)

| Watershed | Stream Identification | Water Use Objectives as Adopted by the Wisconsin Natural Resources Board in 1976 | Water Use Objectives as Recommended by SEWRPC | Rationale for Change Recommended by SEWRPC |
|---|---|---|---|---|
| Minor Streams Tributary to Lake Michigan—Barnes Creek | Barnes Creek | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| *Sucker Creek* | *Sucker Creek at Lake Michigan* | Warmwater fishery and aquatic life, recreational use, and minimum standards | Salmon spawning fishery and aquatic life, recreational use, and minimum standards | Salmon are regularly found in Sucker Creek during the spawning season |
| Pike River | Unnamed perennial stream flowing through the Village of Sturtevant to confluence with Pike River | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Unnamed perennial stream downstream from Town of Somers Utility District No. 1 wastewater treatment plant to confluence with Pike Creek | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Three unnamed tributaries flowing from CTH H east to the confluence with the Pike River, with Pike Creek, and with portions of the Pike River main stem from the headwaters to the Kenosha-Racine County line | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Pike Creek from the headwaters to the confluence with the tributary below the Town of Somers Utility District No. 1 | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Pike Creek from the confluence with the tributary below the Town of Somers Utility District No. 1 to the confluence with Pike River | Limited fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| Rock River | Portions of Jackson Creek flowing through Section 12, Town of Delavan | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Portions of Little Turtle Creek from Lake Road to the Rock/Walworth County Line | Limited fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Tributary to Little Turtle Creek flowing westward through Sections 4 and 5, Town of Sharon | Limited fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |

Table 3 (continued)

| Watershed | Stream Identification | Water Use Objectives as Adopted by the Wisconsin Natural Resources Board in 1976 | Water Use Objectives as Recommended by SEWRPC | Rationale for Change Recommended by SEWRPC |
|---|---|---|---|---|
| Rock River (continued) | Unnamed stream west of Village of Sharon flowing through Sections 31 and 32, Town of Sharon | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Unnamed tributary to the Kohlsville River | Limited fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| Root River | Root River main stem from headwaters to W. Layton Avenue | Warmwater fishery and aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Committed channelization of this stream reach will likely preclude the establishment and maintenance of a warmwater fishery and full recreational use |
| | Hales Corners Creek from headwaters to STH 24 | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | Tess Corners Creek | Limited fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| | East branch Root River Canal from the headwaters to STH 20 | Marginal aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | The water use objectives designated "marginal aquatic life" and "limited fishery (intermediate and aquatic life)" were both incorporated as "limited fishery" under the areawide water quality planning effort. Bottom sediments and channel characteristics preclude full recreational use |
| | East branch Root River Canal from STH 20 to confluence with west branch Root River Canal | Limited fishery and aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Bottom sediments and channel characteristics preclude full recreational use |
| | West branch Root River Canal downstream from Village of Union Grove sewage treatment plant to CTH C | Marginal aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | The water use objectives designated "marginal aquatic life" and "limited fishery" (intermediate aquatic life)" were both incorporated as limited fishery" under the areawide water quality planning effort. Bottom sediments and channel characteristics preclude full recreational use |
| | West branch Root River Canal from CTH C to STH 20 | Limited fishery and aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Bottom sediments and channel characteristics preclude full recreational use |

Table 3 (continued)

| Watershed | Stream Identification | Water Use Objectives as Adopted by the Wisconsin Natural Resources Board in 1976 | Water Use Objectives as Recommended by SEWRPC | Rationale for Change Recommended by SEWRPC |
|---|---|---|---|---|
| Root River (continued) | Root River Canal downstream of the confluence of the east and west branches of the Canal | Warmwater fishery and aquatic life, recreational use, and *minimum standards* | Limited fishery and aquatic life, limited recreational use, and minimum standards | Upstream pollutant discharges and bottom sediments and channel characteristics preclude the establishment and maintenance of a warmwater fishery and impede full recreational use |
| | Hoods Creek | Limited fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an upgraded water use objective |
| Sheboygan River | Portions of the Onion River main stem within the Region | Marginal aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Implementation of the planned water pollution abatement measures will result in a water quality sufficient to permit the assignment of an updated water use objective |

*Source: SEWRPC.*

Table 4

RECOMMENDED CHANGES TO WATER USE OBJECTIVES
PREVIOUSLY ADOPTED BY THE SEWRPC IN WATER QUALITY-RELATED PLANS

| Watershed | Stream Reach or Lake | Previous SEWRPC-Recommended Water Use Objective[a] | Revised SEWRPC-Recommended Water Use Objective | Rationale for Revision |
|---|---|---|---|---|
| Fox River | Genesee Creek from headwaters to confluence with Spring Creek | Warmwater fishery and aquatic life, recreational use, and minimum standards | Trout fishery and aquatic life, recreational use, and minimum standards | Field investigations indicate an existing trout population |
| | Tributary to Sugar Creek in Sections 19 and 20, Town of Spring Prairie | Warmwater fishery and aquatic life, recreational use, and minimum standards | Trout fishery and aquatic life, recreational use, and minimum standards | Field investigations indicate an existing trout population |
| | Lake Geneva | Warmwater fishery and aquatic life, recreational use, and minimum standards | Trout fishery and aquatic life, recreational use, and minimum standards | Field investigations indicate an existing trout population |
| | Buena Lake | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads to the lake cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | Echo Lake | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads to the lake cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | Kee Nong Go Mong Lake | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads to the lake cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | North Lake | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Analyses indicate that a combination of nutrient reduction measures and lake rehabilitation techniques can likely provide the potential to recreational use and the maintenance of a warmwater fishery |
| | Peters Lake | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Analyses indicate that a combination of nutrient reduction measures and lake rehabilitation techniques can likely provide the potential for recreational use and the maintenance of a warmwater fishery |
| | Silver Lake (Walworth County) | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Analyses indicate that a combination of nutrient reduction measures and lake rehabilitation techniques can likely provide the potential for recreational use and the maintenance of a warmwater fishery |

Table 4 (continued)

| Watershed | Stream Reach or Lake | Previous SEWRPC-Recommended Water Use Objective[a] | Revised SEWRPC-Recommended Water Use Objective | Rationale for Revision |
|---|---|---|---|---|
| Kinnickinnic River | Kinnickinnic River | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that the upgraded water quality condition can likely be achieved |
| | Wilson Park Creek | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that the upgraded water quality condition can likely be achieved |
| Menomonee River | Menomonee River main stem from headwaters to USH 41 (Stadium Freeway) | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | Little Menomonee River | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | Butler Ditch | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | Little Menomonee Creek | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | Underwood Creek upstream of Watertown Plank Road | Warmwater fishery and aquatic life, recreational use, and minimum standards | Wa mwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| | Underwood Creek downstream of Watertown Plank Road | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that the upgraded water quality conditions can likely be achieved |
| | Menomonee River main stem from USH 41 (Stadium Freeway) to Falk Corporation Dam | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that the upgraded water quality conditions can likely be achieved |
| | Honey Creek | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that the upgraded water quality conditions can likely be achieved |
| Milwaukee River | Lincoln Creek upstream of Green Bay Road | Restricted use and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that the upgraded water quality conditions can likely be achieved |
| | Lincoln Creek downstream of Green Bay Road | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Analyses indicate that the upgraded water quality conditions can likely be achieved |
| | Indian Creek upstream of IH 43 | Warmwater fishery and aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Stream reach has been lined with concrete, thereby reducing habitat for fish and aquatic life and reducing its potential for recreational use |

Table 4 (continued)

| Watershed | Stream Reach or Lake | Previous SEWRPC-Recommended Water Use Objective[a] | Revised SEWRPC-Recommended Water Use Objective | Rationale for Revision |
|---|---|---|---|---|
| Milwaukee River (continued) | Mud Lake | Warmwater fishery and aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | The bog conditions in Mud Lake preclude the maintenance of a warmwater fishery and most recreational uses |
| Minor Streams Tributary to Lake Michigan | Pike Creek | Restricted use and minimum standards | Warmwater fishery and aquatic life, recreational use, and minimum standards | Analyses indicate that the upgraded water quality conditions can likely be achieved |
| | Sucker Creek estuary | Warmwater fishery and aquatic life, recreational use, and minimum standards | Salmon spawning fishery and aquatic life, recreational use, and minimum standards | Salmon are regularly found in Sucker Creek during the spawning season |
| Rock River | Crooked Lake | Warmwater fishery and aquatic life, recreational use, and minimum standards | Warmwater fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that nutrient loads to the lake cannot as a practical matter be sufficiently reduced to prevent excessive aquatic plant growth which inhibits recreational use |
| Root River | Root River main stem from headwaters to W. Layton Avenue | Warmwater fishery and aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Stream reach is committed to be channelized, thereby reducing habitat for fish and aquatic life and reducing its potential for recreational use |
| | Root River Canal | Warmwater fishery and aquatic life, recreational use, and minimum standards | Limited fishery and aquatic life, limited recreational use, and minimum standards | Analyses indicate that the levels of water quality required to support recreational use and the maintenance of a warmwater fishery probably cannot be achieved as a practical matter |

*[a] The previous SEWRPC-recommended water use objectives were presented in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, for all watersheds except the Menomonee River watershed. For the Menomonee River watershed, the water use objectives were presented in SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed.*

*Source: SEWRPC.*

## Chapter III

## ANTICIPATED GROWTH AND CHANGE

### INTRODUCTION

Change is one of the basic characteristics of the modern world, and urban growth, decay, and renewal are among the most important aspects of this change. No nation, state, or region which participates in modern life can escape the effects of urban change; and no part of daily life can avoid being influenced in some way by forces rooted in this complex process. Changes in population size, composition, and distribution; in economic activity and employment levels; in personal income and public financial resources; and in land use are all inevitable and all have the potential to affect water quality within the Region. Volume One, Chapter III of this report presented data which described the changes in these factors that have occurred over the recent past within southeastern Wisconsin. This chapter presents the results of attempts to forecast the probable magnitude and direction of anticipated changes in these factors, and thereby to provide a basis for the development of a regional water quality management plan. It should be noted that the forecast population and planned land use data for the year 2000 used in preparation of the regional water quality management plan are common to the data used in the preparation of the Commission's regional land use and transportation plans, as well as to other functional elements of the comprehensive regional plan for southeastern Wisconsin, including the regional air quality attainment and maintenance plan.

In any consideration of forecasts, it is important to understand the basic concepts underlying forecasting methodology in general, the methods used to prepare the forecasts under consideration in particular, and the consequent limitations of these forecasts. Therefore, the methodologies and assumptions used in the preparation of the forecasts presented herein are briefly described.

Many methods have been developed for forecasting change in a region, such as southeastern Wisconsin. Some of these methods are quite simple. Some are highly complex. But all are ultimately based upon historical experience and, in general, rely on a combination of mathematical formulation and professional judgment to analyze this experience and project it into the future. The principal difference between or among any of the forecasting methods is generally reflected in the differing emphasis upon these two basic elements. At one extreme, a method may involve little or no mathematical formulation and may depend almost entirely upon the exercise of professional judgment by a person or by a group of persons. Because the variables entering into these forecasts are most often not clearly defined, even in the minds of their authors, such forecasts are generally not capable of reduction to a precise procedure which can be expressed mathematically. At the other extreme, a method may depend almost entirely upon mathematical formulation and require little exercise of professional judgment. Such forecasts, founded as they are in a precise procedure, may be readily replicated once the rules of the procedure are established. These procedural rules may be called forecasting models, and, if expressed in mathematical terms, may be designated as mathematical forecasting models.

It is important to understand that the forecasts based upon mathematical forecasting models are not necessarily more accurate than forecasts based largely upon experienced professional judgment. Forecasts based upon models, however, have two great advantages: they require that the underlying assumptions be explicitly stated; and they permit the effects of differing underlying assumptions to be quantitatively determined. To date, no single mathematical or judgmental method of forecasting any of the basic components of regional change has proven to be more accurate than any other. For this reason, it is generally unwise to rely on the results of a single method of forecasting, but to utilize, if possible, a number of methods; compare the results; and then, after careful consideration of any differences, select the "best" estimate utilizing the most experienced professional judgment available. As measurements of the actual magnitude of change become available in the future, the forecasting methods can be evaluated by comparing the deviation of the observed magnitude of change from the original "best" estimates obtained by alternative methods. This evaluation procedure permits assessment of the validity of the assumptions incorporated into the different forecasting methods and results in refinement of these methods. This procedure has generally been followed in the preparation of forecasts for the regional water quality management plan. It should be noted that many of the basic forecasts presented herein—particularly the demographic, economic, and land use demand forecasts—were initially prepared by the Commission under the regional land use and transportation planning efforts.[1]

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[1] *See SEWRPC Technical Report No. 11, The Population of Southeastern Wisconsin, December 1972; SEWRPC Technical Report No. 10, The Economy of Southeastern Wisconsin, December 1972; and SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, April 1975, and Volume Two, Alternative and Recommended Plans, May 1978.*

The use of these basic forecasts herein helps assure full coordination of the Commission land use and transportation planning efforts with the areawide water quality management planning efforts.

In any consideration of forecasts, it must be recognized that no one can "predict" the future and that all forecasts, however made, involve uncertainty and, therefore, must always be used with great caution. Forecasts cannot take into account events which are unpredictable, but which may have a major effect upon future conditions. Such events include wars; epidemics; major social, political, and economic upheavals; and radical institutional changes. Moreover, both public and private decisions of a less radical nature than the foregoing can be made which may significantly affect the ultimate accuracy of any forecast. The very act of preparing forecasts which present a distasteful situation to society may lead to actions which will negate those forecasts. For these reasons, forecasting, like planning, must be a continuing process. As otherwise unforeseeable events unfold, forecast results must be revised and, in turn, plans which are based on such forecasts must be reviewed and revised accordingly.

Population

The basic procedure followed in the preparation of the regional population forecasts presented herein can be summarized in the following steps:

1. Independent projections[2] were made of the regional population to the year 2000 by four different demographic techniques. These included a regression technique, which converted independently prepared national population projections to regional projections; a technique of projecting population developed by C. Horace Hamilton and Josef Perry;[3] a basic cohort survival technique; and a modified cohort survival technique. Utilizing the basic cohort survival technique alone, 15 population projections were prepared, each based upon different assumptions concerning trends in fertility and migration rates.

2. The separate population projections were converted to employment projections, and independently prepared employment projections were converted to population projections based on an analysis of the relationship between total regional population and employment.

2. A single "best" set of population estimates was then selected from the complete array of projections. This selection was made on the basis of an analysis of the distribution of the array of projections supplemented by the judgment of the Commission staff and Commission advisory committees.

The above procedure produced a forecast of total resident population for the Region to the year 2000. Estimates of the future age and sex characteristics of the regional population were provided by the cohort survival computation and its attendant assumed fertility, mortality, and migration rates which produced the selected population forecast. Estimates of the future number of households and average household size of the regional population were developed on the basis of historic trend information.

Employment

To forecast economic activity and, more particularly, employment within the Region, individual employment projections were made for each of the dominant and subdominant industry groups within the Region. These employment projections were summed, together with the projections of the remaining employment, to arrive at a total employment projection for the Region in the year 2000.

For each dominant and subdominant industry group, a range of employment was projected for the year 2000 from a series of inputs which included:

1. An analysis of historic trends of selected characteristics for each industry group including employment, value added by manufacture, average hourly earnings, and indices of industrial production.

2. An extrapolation of the employment trends in each industry group in the Region from 1950 to 1970.

3. A multiple regression analysis of national, east north-central states, Wisconsin, and regional employment in each industry group from 1950 to 1970.

4. A questionnaire survey of 165 manufacturing firms in the Region.

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[2] *In planning practices, it is conventional to distinguish between "projections" and "forecasts." The former term refers to the result of the application of techniques in which facts about population, employment, or other factors are used to make conditional statements about such factors at later points in time. These projections imply continuation of a stated set of trends. An unconditional assertion about a future condition is formally termed a forecast. Completely unconditional assertions are, however, seldom, if ever, made for planning purposes. Hence, the term "forecast" as used herein refers to population and employment projections used as inputs to nondemographic and noneconomic aspects of plan preparation.*

[3] *The Hamilton-Perry projection technique has only one broad albeit important assumption; that is, that the age-specific rates of fertility, mortality, and migration which operated during the base period of the projection will continue unchanged during the projection period.*

5. Industry outlooks to 1980 as published by the U. S. Department of Commerce.

6. Unpublished forecasts to the year 2000 of national and east north-central states employment by industry group prepared by the National Planning Association.[4]

7. Recent studies of regional business attitudes published by the Bureau of Business Research of the University of Wisconsin.

8. Work force industry projections to the year 1980 published cooperatively by the state government.

From the range of projections so provided, a final regional employment forecast was selected by the Commission staff and Commission advisory committees for use in the reevaluation of the adopted plans. It should be emphasized that the forecast employment levels presented herein are intended to reflect long-term trends and do not presume to account for variations caused by short-term changes in the business cycle.

Land Use

The projection of land use demand as set forth herein is concerned with total regional land use needs regardless of spatial distribution, and is not to be confused with the recommendations for land use contained in the regional land use plan. The regional projections of land use demand are based upon projections of historic trends in land use development. These trend projections were used in the land use plan design process as a point of departure, but the adopted land use plan seeks to modify the future land use conditions from those projections.

The projections of total land use demand to the year 2000 were accomplished by determining the actual average annual change in land use in each of eight major land use categories over the period 1963 through 1970. This average annual change was then projected to the year 2000, and the change in each of the land use categories so calculated for the 1970 to 2000 period was added to or subtracted from the 1970 existing land use to obtain the regional total land use demand for the year 2000.

[4] *The National Planning Association is a private, nonprofit, research organization made up of various standing committees composed of leaders from different specialties and fields. The Association issues policy statements on matters of public concern and disseminates a variety of data, including demographic and economic forecasts on both a national and regional basis.*

Public Financial Resources

The methodology used in forecasting the probable future level of public financial resources available for plan implementation was based upon an extrapolation of historic trends. The forecasts, therefore, do not take into account the effects of any potential changes in the manner in which the revenues are collected and allocated. Desirable as it might be to anticipate significant future realignments in the amounts and sources of the revenues and incorporate the anticipated effects of such realignment into the forecasts, it is not possible to do so in the absence of knowledge about the exact change to be introduced into the system and the time at which such a change is implemented. Two basic forecasts of public expenditures were prepared for the water quality management plan. A forecast was made of the total local government expenditures which may be expected to occur within the Region over the planning period, and a forecast was made of the total water quality management-related expenditures which may be reasonably expected to be made within the Region. Total local government expenditures (excluding school districts) were forecast as follows: historic expenditures from all sources were first adjusted to constant 1976 dollars by using the Consumer Price Index (CPI) for all items in the Milwaukee area as compiled by the U. S. Department of Labor, Bureau of Labor Statistics. The following assumptions concerning the future rates of change in total local government expenditures were then examined:

1. Assumed continuation of the historic trends in the percentage annual change in total expenditures from 1960 through 1972 using an exponential curve to approximate and extend the data series.

2. Assumed continuation of the historic trends in the percentage annual change in per capita expenditures from 1960 through 1972 using an exponential curve to approximate and extend the data series.

3. Assumed continuation of the historic trends in the percentage annual change in total expenditures from 1960 through 1975 using an exponential curve to approximate and extend the data series.

4. Assumed continuation of the historic trends in the percentage annual change in per capita expenditures from 1960 through 1975 using an exponential curve to approximate and extend the data series.

5. Assumed continuation of the historic trends in the absolute annual change in per capita expenditures from 1960 through 1972 using linear regression techniques to identify and extend the historic trend line from the existing data.

6. Assumed continuation of the historic trends in the absolute annual change in per capita expenditures from 1960 through 1975 using linear

regression techniques to identify and extend the historic trend line from existing data.

7. Assumed continuation of the historic trends in the absolute annual change in total expenditures from 1960 through 1972 using linear regression techniques to identify and extend the historic trend line from existing data.

8. Assumed continuation of the historic trends in the absolute annual change in total expenditures from 1960 through 1975 using linear regression techniques to identify and extend the historic trend line from existing data.

9. Assumed continuation of the historic trends in the absolute annual change in per capita expenditures from 1970 through 1975 using linear regression techniques to identify and extend the historic trend line from existing data.

No attempt was made to identify the percentage annual growth trend in per capita expenditures from 1970 to 1975 since a scatter diagram or plot of these existing data points indicated a pattern inappropriate to this form of analysis.

Total water quality management-related expenditures were forecast to the year 2000 simply by calculating the historic ratio of such expenditures to total expenditures, and applying this ratio to forecast total expenditures. Since water quality expenditures, as a proportion of total local government expenditures, have remained relatively stable over the period of record, this technique was deemed a reasonable one.

## POPULATION FORECASTS

### Background

In the 120-year period from 1850 to 1970, the resident population of the Region increased more than 14-fold. This represents an average annual growth rate of 2.6 percent, slightly greater than that of the State of Wisconsin and nearly double that of the United States over the same period. The regional population growth rate, however, has decreased in recent years. From 1960 to 1970, the resident population of the Region increased by only 1.2 percent annually, the second lowest population growth rate over any decade since 1850. Only the decade from 1930 to 1940 showed a slower annual rate of population growth—0.6 percent—reflecting the effects of the severe national economic depression of that decade.

Regional population increases since 1940 have been principally due to natural increase, one of the two major components of population change. Natural increase accounted for 67 percent of the total population increase within the Region from 1950 to 1960 and all of the population increase from 1960 to 1970. Migration accounted for 33 percent of the growth from 1950 to 1960. From 1960 to 1970, however, this migration pattern reversed itself and a net population out-migration from the Region occurred.

During the first three decades of the 1900's, the highest rates of population growth occurred in the now-urban counties of Kenosha, Milwaukee, and Racine. Since 1930, however, the highest rates of population increase have occurred principally in the suburban and rural counties of Ozaukee, Washington, and Waukesha. The 40-year trend of population decentralization from the urban centers to the suburban and rural areas of the Region has important implications for both land use and water quality management planning since the changing demands for public facilities and services, including sewerage facilities and services that result from this population shift, will affect both the older urban centers and the suburban and rural-urban fringe areas of the of the Region.

Regional population increases over the last two decades have been accompanied by significant changes in the age structure of the population. From 1950 to 1960 rapidly rising birth rates and declining death rates resulted in increases in the proportion of the regional population made up of persons under 20 years of age and 65 years of age and older, while the "labor force" segment of the population, from 20 to 64 years of age, actually declined by more than 8 percent. From 1960 to 1970, however, declining birth rates resulted in a decrease in the proportion of the total regional population made up of persons under 10 years of age and an increase in the proportion of the population made up of persons 20 to 64 years of age. The proportion of the population 65 years of age and older increased by 1 percent from 9 percent of the total population in 1960 to 10 percent in 1970.

One population characteristic of particular importance to land use and therefore to water quality management planning is the number and size of households. From 1950 to 1970 the total number of households in the Region increased faster than did the total population residing in households, resulting in a decline in average household size from 3.4 persons per household in 1950 to 3.3 in 1960 and to 3.2 in 1970. This decline in the average number of persons per household is due in part to the dramatic increases in the number of one-person households and to the rapidly declining birthrates since the mid-1960's.

### Probable Future Population Levels

The various population projections prepared by application of the techniques described earlier in this chapter ranged from a high of 3.8 million persons to a low of 1.9 million persons for the Region in the year 2000 (see Table 5). Based upon consideration of the assumptions concerning birth, death, and net migration rates inherent in these projections, and upon comparisons of these projections to independently prepared employment forecasts, the probable range of the future resident population level of the Region was established at between 1.9 and 2.4 million persons by the year 2000. Within this range, a forecast level of 2.2 million persons was finally selected by the Commission staff and advisory committees as the basis for preparation of a new year 2000 regional land use plan and supporting public facilities plan, including the areawide water quality manage-

Table 5

PROJECTED REGIONAL POPULATION IN THE YEAR 2000 USING VARIOUS COMBINATIONS OF FERTILITY AND MIGRATION ASSUMPTIONS

| Projection Number | Fertility and Migration Assumptions | 2000 Population |
|---|---|---|
| 1 | Continuation of current[a] fertility and mortality rates to 2000; migration rates at 1950-60 level. | 3,756,400 |
| 2 | Reduction in fertility to replacement level from 1975 to 2000; migration rates at 1950-60 level; current mortality. | 3,532,000 |
| 3 | Continuation of current fertility and mortality rates to 2000; migration rates at 1950-70 level. | 3,167,700 |
| 4 | Reduction in fertility to replacement level from 1975 to 2000; migration rates at 1950-70 level; current mortality. | 2,968,400 |
| 5 | Continuation of current fertility and migration rates through 1980, then replacement level fertility to 2000; migration rates between the current and the 1950-70 levels to 2000; current mortality. | 2,701,700 |
| 6 | Continuation of current fertility, mortality, and migration rates to 2000. | 2,684,100 |
| 7 | Continuation of current fertility rates to 1985 then replacement level fertility to 2000; continuation of current mortality and migration rates to 2000. | 2,590,100 |
| 8 | Continuation of current fertility rates to 1980, then replacement level fertility to 2000; continuation of current mortality and migration rates to 2000. | 2,560,300 |
| 9 | Reduction in fertility rates to replacement level from 1975 to 2000; continuation of current mortality and migration rates. | 2,506,800 |
| 10 | Reduction in fertility rates to below replacement level from 1975 to 1985, then replacement level fertility to 2000; reversal of net out-migration of the 1960's to net in-migration from 1970 to 2000; current mortality. | 2,427,000[b] |
| 11 | Continuation of current fertility and migration rates to 1985, then replacement level fertility and no migration to 2000; current mortality. | 2,380,800 |
| 12 | Continuation of current fertility and mortality rates to 2000; no migration. | 2,338,300 |
| 13 | Reduction in fertility to below replacement level from 1975 to 1985, then replacement level fertility to 2000; slowdown in the out-migration of the 1960's to a slight net in-migration by 2000; current mortality. | 2,219,300[c] |
| 14 | Reduction in fertility rates to replacement level from 1975 to 2000; continuation of current mortality rates; no migration. | 2,175,200 |
| 15 | Reduction in fertility to below replacement level from 1975 to 1985, then replacement fertility to 2000; continuation of current out-migration and current mortality. | 1,971,800[d] |

[a] *Current refers to 1970 fertility and mortality rates and to 1960-70 migration rates.*

[b] *Selected by Commission staff and advisory committees as the probable upper limit of regional population in 2000.*

[c] *Selected by Commission staff and advisory committees as the best forecast of regional population in 2000.*

[d] *Selected by Commission staff and advisory committees as the probable lower limit of regional population in 2000.*

*Source: SEWRPC.*

ment plan. This forecast population level is based on an assumed reduction in the age-specific fertility rates to below replacement level by 1985 and then a gradual increase to replacement level from 1985 to the year 2000, and on an assumed halt of regional out-migration by 1985 with no substantial net in- or out-migration occurring thereafter.

The assumptions of this forecast appear reasonable in light of recent trends in birthrates and expected fertility, and in light of the anticipation that out-migration should soon reach its limit due to fundamental changes in the components of migration. In the past, migration was largely characterized by rural people moving into urban areas of the eastern, north-central, and midwestern states. This rural pool of potential migration has effectively disappeared, however, and migration is presently characterized by a shift of population from the mature industrialized areas of the eastern, north-central, and midwestern states to the southern and western states in response to the newly developing industrial economies there, with the attendant creation of economic and job opportunities. In time, that shift may be expected to diminish as the unit labor costs in the southern and western states approach those existing in the northeastern, north-central, and midwestern states, and as the growing environmental and developmental problems of the southern and western states begin to increase the costs associated with further urban development there.

Using the overall regional population forecast as a control total, individual population forecasts were developed for each of the seven counties comprising the Region. Specific assumptions about migration, fertility, and mortality were developed for each individual county based upon historical trends in that county and assumptions about future trends. For this reason, the assumptions vary between and among the individual counties. The assumptions of the forecasting model were then iteratively refined until the county forecasts summed to the regional forecast. This procedure is advantageous in that it permits the regional forecast to be used as a control on the county forecasts. Theoretically, the potential relative error of a regional population forecast should be less than the potential relative error of a county population forecast, since the assumptions about future migration, fertility, and mortality can be less specific at the regional level and since the Region affords a larger base population upon which to make a forecast. The net effect of developing the county forecasts within the constraints of the regional forecast should be to reduce the potential relative error of the individual county population forecasts.

As shown on Table 6, the Region's forecast population for the year 2000 represents an increase of about 429,400 persons, approximately 24 percent over the 1975 estimated regional population of 1,789,900 persons. Generally, the revised county population forecasts indicate continued rapid population growth in Ozaukee, Washington, and Waukesha Counties, with slower rates of population growth in Kenosha, Racine, and Walworth Counties. Milwaukee County, currently experiencing

Table 6

REGIONAL POPULATION FORECAST BY COUNTY: 1970-2000

| County | Population | | | | | | |
|---|---|---|---|---|---|---|---|
| | Estimated | | Forecast | | | Difference: 1970-2000 | |
| | 1970[a] | 1975[b] | 1980 | 1990 | 2000 | Number | Percent |
| Kenosha . . . . | 117,917 | 126,651 | 139,200 | 159,900 | 174,800 | 56,883 | 48.2 |
| Milwaukee . . . | 1,054,249 | 1,012,536 | 1,014,500 | 1,022,200 | 1,049,600 | - 4,649 | - 0.4 |
| Ozaukee . . . . | 54,461 | 64,932 | 76,200 | 97,400 | 114,000 | 59,539 | 109.3 |
| Racine. . . . . . | 170,838 | 178,916 | 185,600 | 203,600 | 217,700 | 46,862 | 27.4 |
| Walworth. . . . | 63,444 | 67,511 | 74,700 | 86,600 | 99,600 | 36,156 | 57.0 |
| Washington . . | 63,839 | 76,579 | 90,900 | 117,600 | 143,000 | 79161 | 124.0 |
| Waukesha. . . . | 231,338 | 262,746 | 292,300 | 356,600 | 420,600 | 189,262 | 81.8 |
| Region | 1,756,086 | 1,789,871 | 1,873,400 | 2,043,900 | 2,219,300 | 463,214 | 26.4 |

[a] *These figures represent final 1970 Census of Population and Housing county totals after all adjustments and reallocations have been made by the Census Bureau. As such, these totals may not agree with county population totals shown in other tables in this publication. Adjusted population totals give no information about the social and economic characteristics of the reallocated population, making it impossible to recompile tables of population characteristics to reflect adjusted totals. However, in no county in the Southeastern Wisconsin Region does the final county population total differ from the preliminary county population total by more than 0.1 percent. This is not sufficient to affect the reliability of any table containing the preliminary population totals.*

[b] *These figures represent the final 1975 Wisconsin Department of Administration estimates.*

*Source: U. S. Bureau of the Census, Wisconsin Department of Administration, and SEWRPC.*

a population decline, would continue to lose population until about 1980, when its population would be expected to stabilize and then to begin increasing. The population increase forecast between 1980 and 2000, however, is not expected to fully offset the decrease forecast for the 1970 to 1980 decade, resulting in a small absolute decline of 4,700 persons between 1970 and 2000. Washington and Ozaukee Counties are expected to show the largest relative population gain, increasing by 124 percent and 109 percent, respectively, from 1970 to 2000.

The population forecast envisions a significant decline in the overall rate of population growth within the Region over the next two to three decades. Additionally, the age and sex composition of the regional population is expected to change in accordance with anticipated declines in birthrates and changes in migration patterns. The number of males in the population is expected to increase at a slightly slower rate—26 percent—than the number of females—29 percent—with the resulting expectation that the ratio of males to females will decline from 0.943 in 1970 to 0.922 by 2000. Expected changes in the age composition of the population of the Region are presented in Figure 1 and can be summarized as follows:

1. The age group from 0-4 years of age, representing the preschool population, is expected to increase from about 152,000 persons in 1970 to nearly 161,000 persons in the year 2000, an increase of 9,000 persons, or 6 percent, over the forecast period.

2. The age group from 5-14 years of age, representing the elementary school age population, is expected to decrease from about 367,900 persons in 1970 to about 337,300 persons by the year 2000, a decrease of about 30,600 persons, or 8 percent, over the forecast period.

3. The age group from 15-19 years of age, representing the high school age population, is expected to decline from about 162,200 persons in 1970 to about 151,700 persons by the year 2000, a decrease of about 10,500 persons, or 6 percent, over the forecast period.

4. The age group from 20-64 years of age, representing the working age population of the Region, is expected to increase from about 894,600 persons

in 1970 to about 1,296,400 persons by the year 2000, an increase of about 401,800 persons, or 45 percent, over the forecast period.

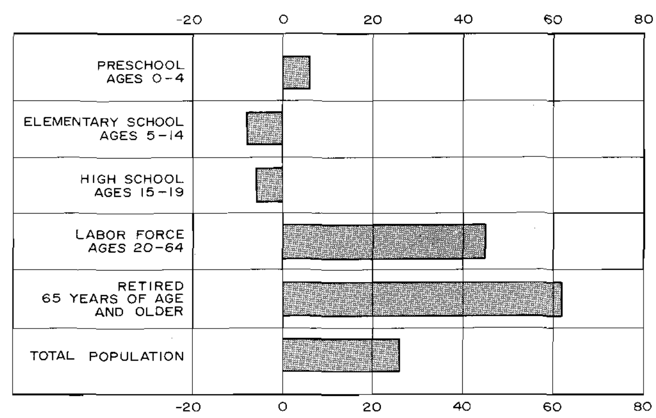
5. The age group 64 years of age and older, representing the elderly population of the Region, is expected to increase from about 168,700 persons in 1970 to about 272,900 persons by the year 2000, an increase of about 104,200 persons, or 62 percent, over the forecast period.

These forecast changes in the age and sex composition of the population have important implications for land use and, therefore, water quality management planning. Initially, these expected changes in population characteristics indicate a reduced need for new school facilities at all levels of education, the reduced need reflecting the expected decline in fertility rates from 1970 to 1985, and the maintenance of replacement fertility rates thereafter. Forecast age changes indicate that the labor force may be expected to increase substantially, and will contain a larger percentage of persons between the ages of 30 and 54 years of age. Accordingly, the number of persons who will be seeking work within the Region may be expected to increase substantially, as will the need to provide jobs for these persons. Finally, these changes indicate that the segment of population over 64 years of age, both in the next 30 years and later as the large working population grows older, may be expected to show the largest relative increase of all age groups, indicating a general aging of the population which will bear upon the demand for housing over at least the next 25 years.

Along with the forecast increases in population will come increases in the number of households in the Region. Forecasts of increases in the number of households have particularly important implications for land use and, therefore, water quality planning, since it is the household population which creates much of the demand for the various land use categories and supporting facilities and services. As shown in Table 7, the number of households in the Region is expected to increase from about 536,500 in 1970 to about 747,700 by 2000, an increase of about 39 percent. Implicit in the forecast are the assumptions that the same proportion of the total population will reside in households in 2000 as did in 1970, and that average household size will continue to decline from its 1970 level. These assumptions are based on an extrapolation of past trends in these population characteristics. The forecast reduction in average household size reflects the assumption that crude birthrates in the forecast period will remain substantially below the pre-1970 rates. This forecast increase in the number of households within the Region by 2000 can be expected to manifest itself in part in an increased demand for housing.

**Figure 1**

**PERCENT CHANGE IN POPULATION OF THE REGION BY SELECTED AGE GROUP: 1970-2000**




*Source: U. S. Bureau of the Census and SEWRPC.*

**Table 7**

**ESTIMATED AND FORECAST HOUSEHOLDS IN THE REGION BY COUNTY: 1970-2000**

| County | 1970 | | | 1980 | | | 1990 | | | 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Households | Household Population | Persons Per Household | Number of Households | Household Population | Persons Per Household | Number of Households | Household Population | Persons Per Household | Number of Households | Household Population | Persons Per Household |
| Kenosha . . . . | 35,468 | 115,712 | 3.26 | 42,800 | 136,574 | 3.19 | 50,400 | 156,860 | 3.11 | 56,800 | 171,466 | 3.02 |
| Milwaukee . . . | 338,605 | 1,029,375 | 3.04 | 358,900 | 990,344 | 2.76 | 376,600 | 997,671 | 2.65 | 400,300 | 1,024,335 | 2.56 |
| Ozaukee . . . . | 14,753 | 53,999 | 3.66 | 21,200 | 75,546 | 3.56 | 27,500 | 96,558 | 3.51 | 32,500 | 113,012 | 3.48 |
| Racine. . . . . . | 49,796 | 167,016 | 3.35 | 55,100 | 181,406 | 3.29 | 61,800 | 198,963 | 3.22 | 67,800 | 212,727 | 3.14 |
| Walworth. . . . | 18,544 | 58,553 | 3.16 | 22,000 | 68,890 | 3.13 | 25,800 | 79,811 | 3.09 | 30,200 | 91,768 | 3.04 |
| Washington . . | 17,385 | 63,167 | 3.63 | 25,300 | 89,937 | 3.55 | 33,800 | 116,344 | 3.44 | 42,300 | 141,468 | 3.34 |
| Waukesha. . . . | 61,935 | 226,776 | 3.66 | 80,200 | 286,491 | 3.57 | 98,700 | 349,457 | 3.54 | 117,800 | 412,149 | 3.50 |
| Region | 536,486 | 1,714,598 | 3.20 | 605,500 | 1,829,188 | 3.02 | 674,600 | 1,995,664 | 2.95 | 747,700 | 2,166,925 | 2.90 |

*Source: U. S. Bureau of the Census and SEWRPC.*

As shown in Table 8 and Figure 2, the regional population is expected to increase by about 27 percent over the forecast period, from 1.76 million persons in 1970 to 2.22 million persons by the year 2000. The regional population growth rate will thus be somewhat higher than that expected for the nation—24 percent—and somewhat lower than that expected for the State—32 percent—over the same period. A slower rate of population growth in the Region than in the State would represent a departure from historic trends, and is indicative of the higher rates of population growth expected in outlying areas of the State—particularly in the northern and western counties.

## EMPLOYMENT FORECASTS

### Background

Population and employment levels in the Region have historically followed quite similar patterns because population migrations between geographic areas are largely dependent upon the availability of jobs in these areas. The rapid historic growth of population in the Region, therefore, may be attributed in part to the increasing economic activity in the Region since the early 1900's. During the last two decades, significant changes in the distribution of economic activity within the Region have occurred as economic activity has decentralized from locations in the long-established urban areas to new suburban and rural locations. This trend is consistent with population movements over these past two decades and characterizes the highly diffuse nature of recent urban development within the Region.

The labor force in the Region increased from 540,000 persons in 1950 to 638,700 persons in 1960, an increase of 18 percent. This growth rate was greater than that for both the State and the nation during this period. From 1960 to 1970 the regional labor force grew by another 17 percent to 744,500 persons, a growth rate slower than that for both the State and nation during this period. Between 1970 and 1975 the regional labor force expanded by an additional 87,000 persons, or by about 12 percent, to the 1975 level of 831,500. This growth rate was again less than that of both the State and nation during this same period. The number of jobs in the Region increased from 552,700 in 1950 to 647,900 in 1960, 741,600 in 1970, and 779,000 in 1975.

Economic activity within the Region is heavily concentrated in capital goods manufacturing. In 1970 the manufacturing sector of the economy represented 34 percent of the total jobs in the Region. By 1975 manufacturing employment had decreased to about 32 percent of the total jobs, but remained the dominant economic activity within the Region. Other important sectors of the economy include private services, which remained stable at about 27 percent of the total employment in

**Table 8**

**POPULATION PROJECTIONS AND FORECASTS FOR THE REGION, WISCONSIN, AND THE UNITED STATES: 1970-2000**

| Year | Population (in thousands) | | |
|---|---|---|---|
| | Region[a] | Wisconsin[b] | United States[c] |
| 1970 | 1,756 | 4,418 | 204,800 |
| 1980 | 1,873 | 4,820 | 220,664 |
| 1990 | 2,044 | 5,384 | 237,678 |
| 2000 | 2,219 | 5,841 | 254,502 |
| Percent Difference 1970-2000 | 26.4 | 32.2 | 24.3 |

[a] *SEWRPC projections.*

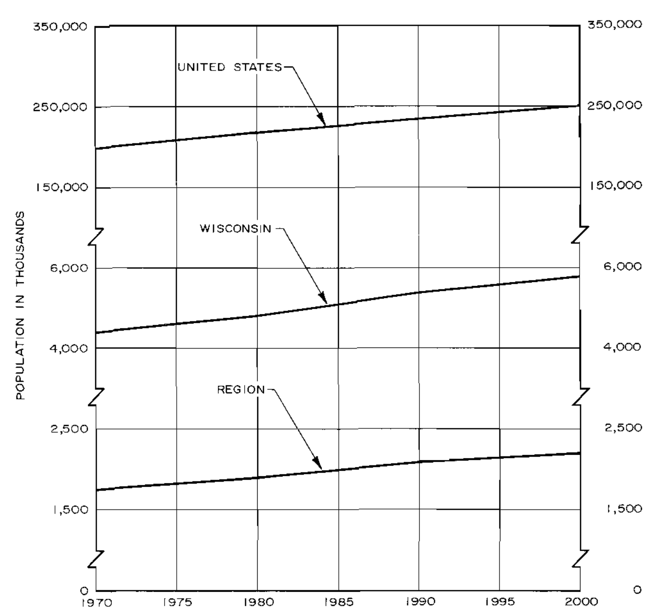
[b] *Wisconsin Department of Administration, Wisconsin Population Projections, Third Edition, June 1975.*

[c] *Figures include armed forces abroad and are Series V projections with immigration, published by the U. S. Bureau of the Census in Current Population Report Series P-25, No. 480, April 1972.*

*Source: U. S. Bureau of the Census, Wisconsin Department of Administration, and SEWRPC.*

**Figure 2**

**COMPARISONS OF POPULATION PROJECTIONS AND FORECASTS FOR THE REGION, WISCONSIN, AND THE UNITED STATES: 1970-2000**




*Source: U. S. Bureau of the Census, Wisconsin Department of Administration, and SEWRPC.*

the Region in 1970 and 1975, and trade, which increased from 19 percent of total employment in 1970 to more than 20 percent in 1975. The largest relative change in employment occurred in the government and educational services sector, which increased by almost 20 percent between 1970 and 1975. This trend of declines in regional manufacturing jobs and increases in jobs in the public and private services reflects national trends of increased demand for consumer goods and services, as well as the decentralization of manufacturing activity away from the older manufacturing belt in the northeast and north-central parts of the nation to the developing industrial economies in the southeastern and western parts of the country. Overall employment in the Region increased by more than 37,000 jobs, or by about 5 percent, between 1970 and 1975; however, 1975 was an atypical year since the nation, State, and Region were then in the midst of an economic recession which severely reduced employment.

Future Employment

Under the conditions and assumptions discussed in SEWRPC Technical Report No. 10, The Economy of Southeastern Wisconsin, December 1972, employment in the Region by the year 2000 was projected to range from 994,500 to 1,101,400 jobs. From this range a forecast regional employment level of 1,048,000 jobs was selected. This forecast employment total was then allocated to the seven counties of the Region based upon an extrapolation of employment trends in each county over the period 1950 through 1970. Monitoring of employment levels from 1971 to 1974 and comparison of those levels against the forecast, particularly at the county level, led to a reevaluation of the employment forecast with respect to both changing trends in the individual county employment patterns and the forecast changing population characteristics noted in the preceding section of the chapter on future population.

In light of the most recent population forecasts, which pointed to a reduction from previously forecast levels in the number of school-age children, it was determined that forecast employment in the educational services category was perhaps too high. Accordingly, forecast employment in this category was subsequently reduced by 32,000 jobs. Employment forecasts for all other categories were deemed to be still valid and were not changed. This revision resulted in a regional employment forecast of 1,016,000 jobs for the year 2000—32,000 jobs less than originally forecast for that year. These 1,016,000 jobs were then allocated to each of the seven counties comprising the Region on the basis of county employment trends over the period 1955 through 1974. A comparison of the year 2000 employment forecasts with 1970 and 1975 estimated employment is shown in Table 9.

The distribution and staging of the regional employment forecast for each of the seven counties for the years 1980, 1990, and 2000 are shown in Table 9 and Figure 3. Regional employment is expected to increase to 833,000 jobs by 1980, to 924,500 jobs by 1990, and to the forecast level of 1,016,000 jobs by 2000. The year 2000 regional employment forecast indicates an expected increase of 274,400 jobs, or 37 percent, over the 1970 level. This represents an average annual increase of 9,150 jobs, or 1.2 percent, over the next 30 years.

**Table 9**

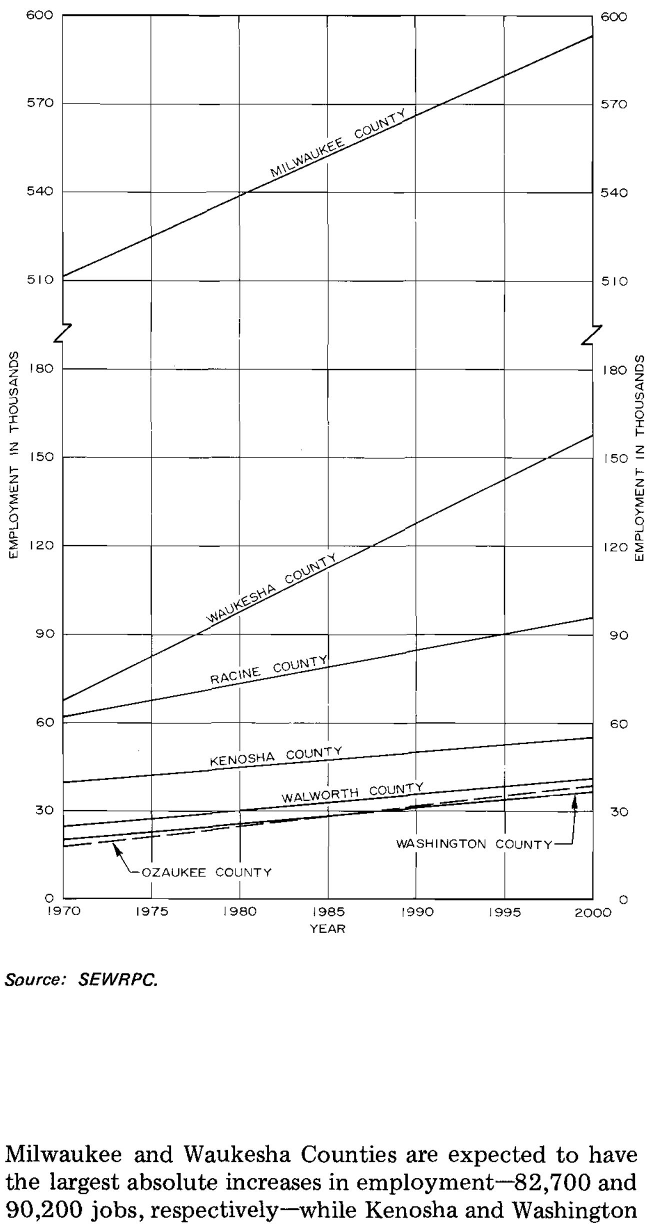
**ESTIMATED EMPLOYMENT AND REGIONAL EMPLOYMENT FORECAST BY COUNTY: 1970, 1975, 1980, 1990, AND 2000**

| County | Employment | | | | | | |
|---|---|---|---|---|---|---|---|
| | Estimated | | Forecast | | | Difference: 1970-2000 | |
| | 1970 | 1975 | 1980 | 1990 | 2000 | Number | Percent |
| Kenosha | 39,200 | 46,700 | 44,200 | 49,300 | 54,300 | 15,100 | 38.5 |
| Milwaukee | 510,900 | 515,700 | 538,400 | 566,000 | 593,600 | 82,700 | 16.2 |
| Ozaukee | 17,900 | 20,200 | 24,600 | 31,300 | 38,000 | 20,100 | 112.3 |
| Racine | 61,900 | 68,600 | 73,100 | 84,300 | 95,500 | 33,600 | 54.3 |
| Walworth | 24,200 | 25,700 | 29,900 | 35,500 | 41,200 | 17,000 | 70.2 |
| Washington | 20,300 | 22,600 | 25,500 | 30,800 | 36,000 | 15,700 | 77.3 |
| Waukesha | 67,200 | 79,500 | 97,300 | 127,300 | 157,400 | 90,200 | 134.2 |
| Region | 741,600 | 779,000 | 833,000 | 924,500 | 1,016,000 | 274,400 | 37.0 |

*Source: SEWRPC.*

Figure 3

FORECAST EMPLOYMENT LEVELS IN THE REGION BY COUNTY: 1970-2000




*Source: SEWRPC.*

Milwaukee and Waukesha Counties are expected to have the largest absolute increases in employment—82,700 and 90,200 jobs, respectively—while Kenosha and Washington Counties are expected to have the smallest absolute increases—15,100 and 15,700 jobs, respectively. The largest relative rates of employment growth are expected in Ozaukee and Waukesha Counties—112 percent and 134 percent, respectively—while the smallest relative rate of employment growth, 16 percent, is expected in Milwaukee County. Employment in Milwaukee County is expected to decline in relation to the regional total, reflecting a continued decentralization of economic activity from the highly urbanized areas of the Region. While Milwaukee County's employment is expected to increase from 510,900 jobs in 1970 to 593,600 jobs by 2000, the County's share of total regional jobs is expected to decline from 69 percent to 58 percent. Waukesha County is expected to increase its share of regional jobs from 67,200 jobs in 1970, representing 9 percent of total regional employment, to 157,400 jobs by the year 2000, or to more than 15 percent of the regional employment. The Counties of Ozaukee, Racine, Walworth, and Washington are all expected to increase their share of regional employment by about 1 percent between 1970 and 2000, while Kenosha County is expected to maintain its share of regional employment at about 5 percent over the forecast period.

These expected trends in forecast county employment are generally consistent with expected population increases from 1970 to 2000 which reflect an overall decentralization of population and economic activity from the established urban areas of the Region to suburban and rural locations. This phenomenon is not unique to the Southeastern Wisconsin Region, but is now characteristic of many of the older established urbanized areas of the nation. It should be emphasized that the forecasts reflect the use of certain documented data and stated assumptions and judgments concerning trends in economic activity within the Region. As new data reveal new trends, revisions will undoubtedly have to be made to the forecasts in order to maintain their usefulness. Further, the forecasts presented do not take into account variations caused by short-term business cycles or any unpredictable economic dislocation.

Major industry group employment forecasts to the year 2000 are shown in Table 10 and Figure 4. Between 1970 and 2000 employment in the trade, government, and education services, and in private services groups may be expected to show relative increases greater than the regional employment increase of 37 percent. Employment in manufacturing, while increasing at a rate approximately 10 percent below the regional employment rate increase, may be expected to continue to be the largest employment group with 320,300 jobs by 2000. Private services may be expected to constitute the second largest employment group with 276,800 jobs in that year. Agriculture is the only industry group expected to decline in employment from 1970 to 2000. As shown in Table 10, agricultural employment in the Region is expected to decline from 10,600 jobs in 1970 to 7,500 jobs in the year 2000, a decrease of 3,100 jobs, or 29 percent. This expected decline in agricultural employment in the Region is a continuation of an established trend and is due, in part, to the continued mechanization of farming processes, the increasing size of the farms within the Region, and the loss of farmland in the Region through the conversion of land from agricultural to urban use.

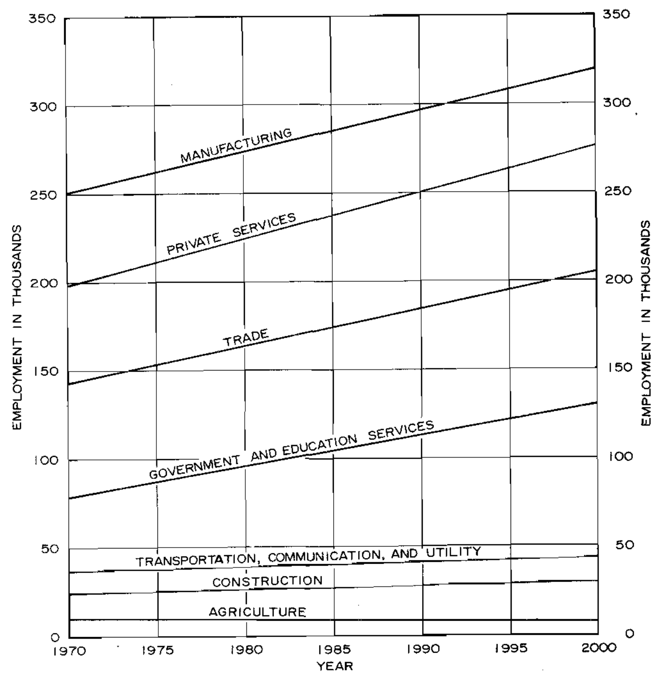
Generally, the rapid increases in employment expected in the service and other consumer-oriented industry groups and the corresponding slower rates of employment growth expected in the manufacturing industry groups by the year 2000 are continuations of already established trends. These represent a change in the orientation of the regional economy over the past 20 years and were probably brought about by the maturation of the Region's manufacturing base and subsequent increases in consumer spending for services and retail goods. It should be noted, however, that recently enacted business and industry tax changes in Wisconsin, which are intended to provide investment incentives especially to manufacturing industries, may encourage expansion of existing manufacturing industries as well as encourage new manufacturing industries to locate in the Region.

Since the manufacturing industry group represents the largest single regional employer in 1970, a breakdown of the major manufacturing industry forecast employment level is shown in Table 11 and Figure 5. As shown, the largest relative increase in employment from 1970 to the year 2000 is expected in the fabricated metals industry. The forecast employment level in this industry indicates an increase of 16,800 jobs, or 68 percent, from 24,600 jobs in 1970 to a forecast level of 41,400 jobs in the year 2000. The expected growth in employment in the fabricated metals industry is based on an increasing demand for such products as metal cans and containers used in food packaging.

The primary metals industry is expected to show an employment increase from 22,500 jobs in 1970 to 32,400 jobs in the year 2000, an increase of 9,900 jobs, or 44 percent. The expected increase in employment for this industry is based upon a projected increase in demand for primary metal products, such as ferrous castings. This demand is expected to increase by 3 percent annually through the 1970's.

Figure 4

FORECAST EMPLOYMENT LEVELS IN THE REGION BY MAJOR INDUSTRY GROUP: 1970-2000




Source: SEWRPC.

Table 10

FORECAST EMPLOYMENT LEVELS IN THE REGION BY MAJOR INDUSTRY GROUP: 1970, 1975, 1980, 1990, AND 2000

| Major Industry Group | Employment (in thousands) | | | | | Difference 1970-2000 | |
|---|---|---|---|---|---|---|---|
| | 1970 | 1975 | 1980 | 1990 | 2000 | Number | Percent |
| Agriculture | 10.6 | 10.3 | 9.5 | 8.3 | 7.5 | - 3.1 | - 29.2 |
| Construction | 24.0 | 23.3 | 26.0 | 28.0 | 30.1 | 6.1 | 25.4 |
| Manufacturing | 251.0 | 248.0 | 274.1 | 297.2 | 320.3 | 69.3 | 27.6 |
| Trade | 143.2 | 160.5 | 164.3 | 185.4 | 206.4 | 63.2 | 44.1 |
| Transportation, Communication, and Utility | 36.0 | 35.1 | 38.5 | 41.2 | 43.7 | 7.7 | 21.4 |
| Private Services | 198.1 | 207.6 | 224.4 | 250.7 | 276.8 | 78.7 | 39.7 |
| Government and Education Services | 78.7 | 94.2 | 96.2 | 113.7 | 131.2 | 52.5 | 66.7 |
| Total | 741.6 | 779.0 | 833.0 | 924.5 | 1,016.0 | 274.4 | 37.0 |

Source: SEWRPC.

Table 11

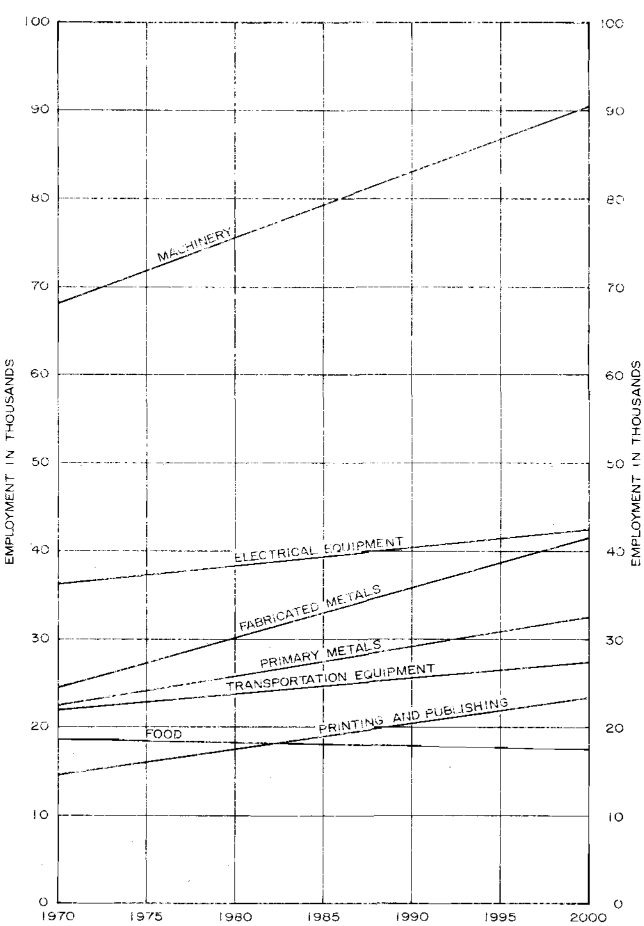
FORECAST MANUFACTURING EMPLOYMENT LEVELS IN THE REGION BY MANUFACTURING INDUSTRY GROUP: 1970, 1975, 1980, 1990, AND 2000

| Manufacturing Industry Group | Employment (in thousands) | | | | | Difference 1970-2000 | |
|---|---|---|---|---|---|---|---|
| | 1970 | 1975 | 1980 | 1990 | 2000 | Number | Percent |
| Food and Related Products . . . . . | 18.9 | 19.1 | 18.5 | 18.1 | 17.6 | - 1.3 | - 6.9 |
| Printing and Publishing. . . . . . . . | 14.9 | 14.1 | 17.7 | 20.5 | 23.3 | 8.4 | 56.4 |
| Primary Metals . . . . . . . . . . . . . | 22.5 | 22.6 | 25.8 | 29.1 | 32.4 | 9.9 | 44.0 |
| Fabricated Metals . . . . . . . . . . . | 24.6 | 24.9 | 30.2 | 35.8 | 41.4 | 16.8 | 68.3 |
| Machinery . . . . . . . . . . . . . . . . | 68.1 | 68.4 | 76.0 | 83.9 | 91.9 | 23.8 | 34.9 |
| Electrical Equipment . . . . . . . . . | 36.5 | 35.5 | 38.5 | 40.5 | 42.6 | 6.1 | 16.7 |
| Transportation Equipment . . . . . | 22.0 | 25.0 | 23.9 | 25.8 | 27.6 | 5.6 | 25.4 |
| Miscellaneous Manufacturing . . . . | 43.5 | 38.4 | 43.5 | 43.5 | 43.5 | -- | -- |
| Total | 251.0 | 248.0 | 274.1 | 297.2 | 320.3 | 69.3 | 27.6 |

*Source: SEWRPC.*

Figure 5

FORECAST MANUFACTURING EMPLOYMENT LEVELS IN THE REGION BY MANUFACTURING INDUSTRY GROUP 1970-2000




*Source: SEWRPC.*

The Region's largest manufacturing employer, nonelectrical machinery and equipment, is expected to show an employment increase from 68,100 jobs in 1970 to 91,900 jobs in the year 2000, an increase of 23,800 jobs, or 35 percent. Nationally, growth in the output of this industry is projected to range from 5 to 6 percent annually through the 1970's. In addition, national employment projections in this industry indicate an annual rate of growth of 1.5 percent to the year 2000. Within the Region, the nonelectrical machinery industry has shown locational disadvantages. Thus, increases in regional employment in this industry are seen to be relatively modest.

One industry group, food and beverage products, is expected to decline in employment between 1970 and the year 2000. This industry is expected to show an absolute decline in employment from 18,900 jobs in 1970 to 17,600 jobs in the year 2000, a decrease of 1,300 employees, or 7 percent. The forecast decline in this industry is based on employment trends in the Region which show slow but steady declines in employment over the past two decades. In addition, many of the processes involved in food processing, particularly in the brewing industry, are becoming highly mechanized. This forecast level represents a virtual stabilization of employment in this industry over the next 25 years.

The electrical equipment and transportation equipment industries are expected to show modest increases in employment from 1970 to the year 2000. Employment in the electrical equipment industry is expected to increase by 25 percent over the period. It should be noted that the nature of the transportation equipment industry in the Region, with only a few firms operating in a highly competitive market, makes long-term forecasts in this industry's employment subject to a wide range of error.

Four industries—printing and publishing, primary metals, fabricated metals, and nonelectrical machinery—are expected to show employment increases greater than the increases in total regional manufacturing employment from 1970 to 2000. The remaining manufacturing industries—food and beverage products, electrical equipment, and transportation equipment—are expected to show employment increases at rates lower than the expected employment increases in total regional manufacturing employment.

## LAND USE DEMAND

### Background

Although the Region has continuously experienced major changes in land use since its settlement by Europeans in the middle 1800's, the period from 1950 to 1963 was marked by particularly drastic changes in land use development. While the population of the Region increased by about 433,700 persons, or by 35 percent, over this 13-year period, the amount of land devoted to urban use increased by 146 percent. Consequently, the density of the developed urban area of the Region declined sharply from about 8,500 persons per square mile in 1950 to about 4,800 persons per square mile in 1963. This urban diffusion and decline in urban population density continued, but at a more moderate rate, from 1963 to 1970, over which period the density of the developed urban area of the Region fell further to a level of about 4,350 persons per square mile.

About 129,000 acres, or about 202 square miles of land in the Region, were converted from rural to urban use from 1950 to 1963, or about 15.5 square miles per year. About half of the total of the 202 square miles of land converted to urban use from 1950 to 1963, or more than 100 square miles, was converted to residential use. In addition to this conversion for residential use, approximately 65,000 acres, or about an additional 100 square miles of land, were converted to other urban uses. Major changes in the concepts relating to the development of major activity centers, such as industrial parks, major shopping centers, and higher educational centers, substantially increased the land devoted to these major uses. The provision of large areas for offstreet parking in conjunction with these various major land uses was a major, but not the only, contributing factor to this increase in land area devoted to these uses.

The changes in land use that occurred within the Region from 1963 to 1970 are summarized in Table 12, which indicates that a total of 74 square miles of land were

**Table 12**

**PROJECTED LAND USE DEMAND IN THE REGION: 1970-2000**

| Land Use Category | Existing Land Use[a] 1963 Acres | Existing Land Use 1963 Square Miles | Existing Land Use 1970 Acres | Existing Land Use 1970 Square Miles | Existing Land Use 1970 Percent of Region | 1963-1970 Difference Acres | 1963-1970 Difference Square Miles | 1963-1970 Difference Percent | Average Annual Change 1963-1970 Acres | Average Annual Change 1963-1970 Square Miles | Average Annual Change 1963-1970 Percent | 1970-2000 Projected Difference[b] Acres | 1970-2000 Projected Difference Square Miles | 1970-2000 Projected Difference Percent | Total Projected Land Use 2000 Acres | Total Projected Land Use 2000 Square Miles | Total Projected Land Use 2000 Percent of Region |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residential | 129,219 | 201.91 | 156,266 | 244.17 | 9.1 | 27,047 | 42.26 | 20.9 | 3,863 | 6.04 | 3.00 | 115,890 | 181.09 | 74.2 | 272,156 | 425.24 | 15.8 |
| *High Density* | *21,471* | *33.55* | *25,401* | *39.69* | *1.5* | *3,930* | *6.14* | *18.3* | *561* | *0.88* | *2.61* | *16,830* | *26.30* | *66.3* | *42,231* | *65.99* | *2.5* |
| *Medium Density* | *31,596* | *49.37* | *43,230* | *67.55* | *2.5* | *11,634* | *18.18* | *36.8* | *1,662* | *2.60* | *5.26* | *49,860* | *77.91* | *115.3* | *93,090* | *145.45* | *5.4* |
| *Suburban and Low Density* | *76,152* | *118.99* | *87,635* | *136.93* | *5.1* | *11,483* | *17.94* | *15.1* | *1,640* | *2.56* | *2.16* | *49,200* | *76.88* | *56.1* | *136,835* | *213.80* | *7.9* |
| Retail Sales and Service[c] | 6,759 | 10.56 | 9,464 | 14.79 | 0.6 | 2,705 | 4.23 | 40.0 | 387 | 0.61 | 5.71 | 11,610 | 18.14 | 128.0 | 21,074 | 32.93 | 1.2 |
| Industrial[c] | 9,668 | 15.11 | 11,383 | 17.79 | 0.7 | 1,715 | 2.68 | 17.7 | 245 | 0.38 | 2.53 | 7,350 | 11.48 | 64.5 | 18,733 | 29.27 | 1.1 |
| Transportation, Communication, and Utilities[c] | 96,121 | 150.19 | 103,350 | 161.48 | 6.0 | 7,229 | 11.29 | 7.5 | 1,033 | 1.61 | 1.07 | 30,990 | 48.42 | 30.0 | 134,340 | 209.91 | 7.8 |
| Governmental and Institutional[c] | 14,910 | 23.30 | 17,878 | 27.93 | 1.0 | 2,968 | 4.63 | 19.9 | 424 | 0.66 | 2.84 | 12,720 | 19.87 | 71.1 | 30,598 | 47.81 | 1.8 |
| Recreational[d] | 23,548 | 36.79 | 29,502 | 46.10 | 1.7 | 5,954 | 9.31 | 25.3 | 851 | 1.33 | 3.61 | 25,530 | 39.89 | 86.5 | 55,032 | 85.99 | 3.2 |
| Total Urban | 280,225 | 437.86 | 327,843 | 512.26 | 19.1 | 47,618 | 74.40 | 17.0 | 6,803 | 10.63 | 2.43 | 204,090 | 318.89 | 62.3 | 531,933 | 831.15 | 30.9 |
| Agricultural | 1,083,800 | 1,693.44 | 1,040,121 | 1,625.19 | 60.4 | -43,679 | -68.25 | -4.0 | -6,240 | -9.75 | -0.57 | -187,200 | -292.50 | -18.0 | 852,921 | 1,332.69 | 49.6 |
| Other Open Lands[f] | 357,075[e] | 557.93[e] | 353,136 | 551.78 | 20.5 | -3,939 | -6.15 | -1.1 | -563 | -3.00 | -0.16 | -16,890 | -26.39 | -4.8 | 336,246 | 525.39 | 19.5 |
| Total Rural | 1,440,875[e] | 2,251.37[e] | 1,393,257 | 2,176.97 | 8.09 | -47,618 | -74.40 | -3.3 | -6,803 | -10.63 | -0.47 | -204,090 | -318.89 | -14.6 | 1,189,167 | 1,858.08 | 69.1 |
| Region Total | 1,721,030[e] | 2,689.23[e] | 1,721,100 | 2,689.23 | 100.0 | -- | -- | -- | -- | -- | -- | -- | -- | -- | 1,721,100 | 2,689.23 | 100.0 |

[a] *Based on SEWRPC regional land use inventories conducted in April 1963 and April 1970.*

[b] *Based on a 30-year projection of the 1963-1970 average annual change.*

[c] *Includes related offstreet parking.*

[d] *Includes only "active" recreation areas within parks or parkways and related offstreet parking. All other uses within parks or parkways are tabulated in the appropriate land use category.*

[e] *Includes 85 acres added to make the 1963 and 1970 data directly comparable.*

[f] *Includes water, wetlands, woodlands, unused lands, and quarries.*

*Source: SEWRPC.*

converted from rural to urban uses during this seven-year period, or an average of about 10.6 square miles per year. As in the 1950 to 1963 period, about half of the land converted during the period 1963 to 1970 was converted to accommodate residential use. During this period, however, the two major land uses experiencing the highest percentage increase were retail sales and service lands and lands devoted to recreational use. The land use showing the lowest percentage increase during this period was the transportation, communication, and utilities category. Agricultural and other open lands were reduced by the increases in urban land, the bulk of the loss occurring in agricultural lands.

Probable Future Land Use Demand

As shown in Table 12, Commission projections indicate that if existing trends in land use development continue within the Region, contrary to recommendations contained in the adopted regional land use plan, nearly 319 square miles of land may be expected to be converted from rural to urban use during the 30-year period from 1970 to the year 2000, an increase of about 62 percent over the 1970 urban land totals. The projections further indicate that the bulk of this conversion to urban use may be expected, in the absence of a regional land use plan and vigorous implementation of that plan, to occur within the agricultural areas, with approximately 293 square miles of agricultural land being converted during the 30-year period. This projected conversion of land from rural to urban use would result in major changes in the regional land use pattern. For example, in 1970 urban land uses accounted for approximately 19 percent of the total area of the Region. Based upon the projections, nearly 31 percent of the Region would be devoted to urban use by the year 2000, a substantial increase. Similarly, rural land uses that accounted for nearly 81 percent of the land area of the Region in 1970 would be reduced to approximately 69 percent by the year 2000.

Urban population density within the Region is one of the important factors which must be considered in the preparation of the land use and water quality management plans. Based on the 1970 regional population of 1,756,086, the forecast regional population for the year 2000 of 2,219,300 and the projected demand for land, major changes in urban densities in the Region may be expected to occur. In 1970 the gross population density of the developed urban land within the Region approximated 4,350 persons per square mile. If the projected land use demand is met entirely through the conversion of rural land to urban use, the overall density of the developed urban area of the Region can be expected to fall to about 2,300 persons per square mile by the year 2000.

It should be noted that these land use projections are not plans, nor should the numbers provided by such projections be construed as the numbers to which land use plans must adhere. In the preparation of alternative land use plans, recommendations may be made to change the projected course of events in terms of land conversion to bring about a more efficient, healthful, and attractive regional settlement pattern. Similarly, plans that will be prepared using the projections are not to be construed as forecasts or projections, but as what they are—plans that are intended to be used as a guide in shaping regional development. Considerable confusion exists concerning the difference between a land use plan with accompanying population distribution, employment, and land use data and the forecasts and projections used in the preparation of such a plan. It is essential that the significant but subtle differences between forecasts, projections, and plans be understood. Forecasts and projections are intended to indicate what "might be" in the absence of plans. Plans recommend what "should be."

## PUBLIC EXPENDITURES FORECAST

Background

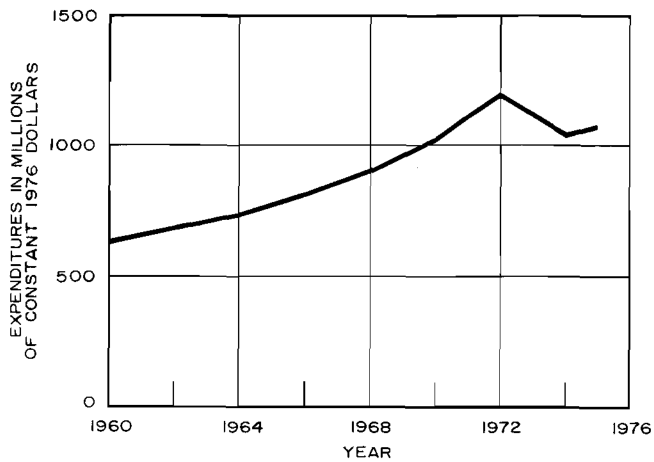
The implementation of any water quality management plan requires that the local units of government which represent the public sector of the regional economy, as well as the private sector which is comprised of agriculture, industry, and commerce, have the necessary financial ability to fund the areawide plan. It is the purpose of this section to discuss the probable future funding capabilities of the Region with respect to water quality management expenditures, relating this capability to probable total public expenditures levels and to the economic future of the Region. A well-financed water quality management plan should enhance the economy of the Region by providing for efficient use of resources and an environment favorable to growth and development.

From 1960 to 1972, the level of expenditures made by the general-purpose units of government in the Region showed steady increases; however, since 1972 the levels have fluctuated, first dropping and then rising, but not exceeding the peak expenditure levels of 1972 as indicated in Figure 6. This change in the expenditure pattern of the local units of government may be attributed to a number of reasons. State-imposed levy limits were placed in effect in 1972 which limit tax levy increases to the rate of increase of total state equalized property values. Since the property tax constitutes the largest share of local revenues, this limit may be expected to affect expenditures as well. An examination of the historic growth trend of property values, as set forth in Figure 7, indicates, however, that statewide assessed valuations have shown continuous growth. In addition, since 1972 the State has assumed responsibility for funding a number of public services, especially in the area of health and social services, thereby lowering the associated local expenditures.

This period of recorded decreases in public expenditures was also a period of economic recession at the local, state, and national level. This downturn in the economy may have had a corresponding impact upon the governmental spending patterns. Public expenditures, when expressed in current dollars, show an apparent increase. This apparent increase, however, becomes an actual decrease, as shown in Figure 8, when the expenditures are converted to constant dollars, due to the extremely high inflation rates which occurred in 1973 and 1974.

Figure 6

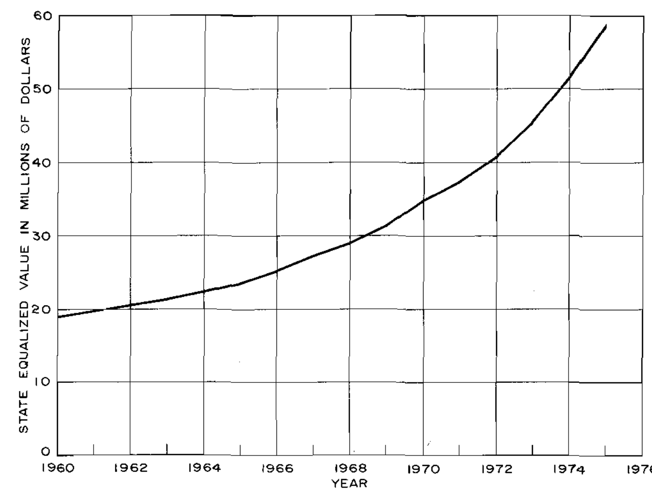
REPORTED EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE REGION: 1960-1975




*Source: Wisconsin Department of Revenue, Bureau of Audit and SEWRPC.*

Figure 7

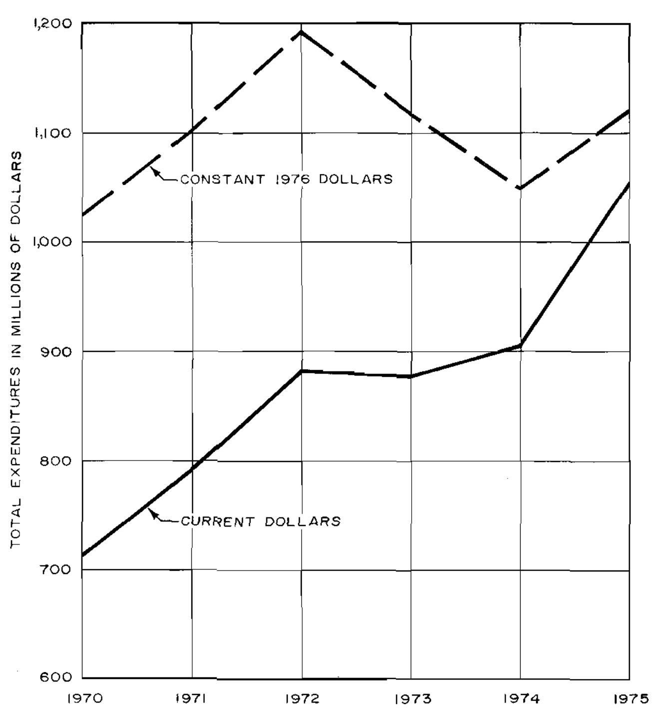
STATE EQUALIZED ASSESSED VALUE OF ALL PROPERTY IN THE STATE: 1960-1975




*Source: Wisconsin Department of Revenue and SEWRPC.*

Figure 8

TOTAL EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE REGION: 1970-1975




*Source: Wisconsin Department of Revenue, Bureau of Municipal Audit and SEWRPC.*

The increase in expenditures, expressed in constant dollars, which occurred in 1975 would seem to be consistent with the previously established trend and thus would signal a return to the long-term expenditure patterns which existed prior to 1973.

Water quality management-related expenditures reflect a pattern similar to those of total expenditures for the local units of government, as shown in Table 13. Whereas the cause of the decrease in overall expenditures is largely speculative, the decrease in water quality management-related expenditures is the result of reduced capital expenditures as discussed in Volume One, Chapter VII of this report.

The relative expenditure pattern for water quality-related items is one of consistency, with water quality management-related expenditures ranging from 10.8 percent to 10.3 percent of the total expenditures made by local units of government and averaging 10.6 percent, as shown in Table 14. This relative level of expenditure for water quality management-related items by the government units is less than the historic expenditures for transportation, which averaged about 16 percent of the total, and much less than the expenditures for health and welfare, which historically constituted almost 30 percent of the total expenditures and as such represented the largest expenditure category for the governmental units in the Region.

Future Expenditures

Total expenditures by local units of government (excluding school districts) were forecast in constant 1976

Table 13

TOTAL REPORTED WATER QUALITY-RELATED EXPENDITURES BY UNIT OF GOVERNMENT IN THE REGION: 1971-1975

| Unit of Government | Expenditures (in millions of constant 1976 dollars) | | | | | Difference 1971-1975 | |
|---|---|---|---|---|---|---|---|
| | 1971 | 1972 | 1973 | 1974 | 1975 | Absolute | Percent |
| Milwaukee County[a] | $ 31.1 | $ 37.3 | $ 23.6 | $ 14.2 | $ 15.4 | - 15.7 | - 50.5 |
| All Counties (excluding Milwaukee County) | 1.1 | 1.4 | 2.5 | 2.7 | 2.5 | 1.4 | 127.3 |
| City of Milwaukee[b] | 34.3 | 31.5 | 37.8 | 35.7 | 28.7 | - 5.6 | - 16.3 |
| All Cities (excluding Milwaukee)[b] | 38.6 | 45.2 | 39.0 | 44.9 | 52.6 | 14.0 | 36.0 |
| Villages | 11.4 | 8.8 | 15.6 | 6.8 | 13.0 | 1.6 | 14.0 |
| Towns | 2.3 | 2.2 | 2.4 | 3.6 | 3.3 | 1.0 | 43.5 |
| Region | 118.8 | 126.4 | 120.9 | 107.9 | 115.5 | - 3.3 | - 2.8 |

[a] *Includes the expenditures for capital projects undertaken by the Metropolitan Sewerage Commission.*

[b] *Includes the expenditures for operation and maintenance of the Metropolitan Sewerage Commission.*

*Source: Wisconsin Department of Revenue, Bureau of Municipal Audit and SEWRPC.*

Table 14

REPORTED WATER QUALITY EXPENDITURES AS A PERCENTAGE OF TOTAL EXPENDITURES FOR THE LOCAL UNITS OF GOVERNMENT IN THE REGION: 1971-1975

| Unit of Government | 1971 | 1972 | 1973 | 1974 | 1975 | Average |
|---|---|---|---|---|---|---|
| Milwaukee County | 8.6 | 9.7 | 6.3 | 4.1 | 4.4 | 6.6 |
| Remaining Counties | 1.0 | 1.0 | 1.6 | 2.1 | 1.7 | 1.5 |
| City of Milwaukee | 11.2 | 9.5 | 12.8 | 12.6 | 11.1 | 11.4 |
| Remaining Cities | 16.3 | 18.4 | 17.9 | 21.6 | 19.7 | 18.8 |
| Villages | 19.8 | 15.4 | 27.4 | 11.1 | 23.0 | 19.3 |
| Towns | 11.6 | 10.0 | 10.6 | 19.3 | 16.1 | 13.5 |
| Region | 10.8 | 10.6 | 10.8 | 10.3 | 10.3 | 10.6 |

*Source: SEWRPC.*

dollars using a number of differing assumptions as discussed earlier in the chapter. The forecast total expenditure levels for the year 2000 in the Region ranged from $1,480 million to $4,070 million, as shown in Table 15. Within this range, a level of $2,330 million was selected by the Commission staff as being most representative of probable future expenditure levels for these reasons: first, the method used, linear regression, is internally consistent with the methodology used in previous Commission work efforts; second, the data period of 1960 through 1975 is the most current sequence available to the Commission and as such reflects current economic trends as well as the long-term trends in expenditure patterns; and third, this level of $2,330 million represents a relatively conservative forecast which reflects the recent concerns about government spending and the uncertainty of the overall economic environment. This forecast level of $2,330 million represents an increase of $1,210 million, or 108 percent, over the $1,120 million expended in 1975, and further represents an annual real growth rate of 3 percent in expenditures. This annual growth rate of 3 percent is about half of the annual growth rate between 1960 and 1972 and is based on the expected real growth which should occur in the national and regional economy.

Table 15

PROJECTED TOTAL EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE REGION IN THE YEAR 2000 USING VARIOUS COMBINATIONS OF METHODS AND DATA BASES

| Projection Number | Method | Data Base | Total 2000 Expenditures[a] (in millions of 1976 dollars) |
|---|---|---|---|
| 1 | Compound annual percentage growth | Total expenditures, 1960 through 1972 | 4,070 |
| 2 | Compound annual percentage growth | Per capita expenditures, 1960 through 1972 | 3,885 |
| 3 | Compound annual percentage growth | Total expenditures, 1960 through 1975 | 2,845 |
| 4 | Compound annual percentage growth | Per capita expenditures, 1960 through 1975 | 2,836 |
| 5 | Linear regression | Per capita expenditures, 1960 through 1972 | 2,672 |
| 6 | Linear regression | Per capita expenditures, 1960 through 1975 | 2,613 |
| 7 | Linear regression | Total expenditures, 1960 through 1972 | 2,358 |
| 8 | Linear regression | Total expenditures, 1960 through 1975 | 2,330 |
| 9 | Linear regression | Per capita expenditures, 1970 through 1975 | 1,480 |

[a]*Does not include school districts.*

*Source: SEWRPC.*

The high forecast amount was felt to be unrealistic since it was based on trends which occurred during a period of rapid population and economic growth. The low forecast level was based on a trend which was largely affected by the recent recession, and thus was probably not truly indicative of future conditions. The forecast increase in total expenditures represents a per capita increase in expenditures from $625 in 1975 to approximately $1,050 in the year 2000—a 68 percent increase.

Based on the range of total expenditure forecasts, water quality expenditures could be expected to range from $157 million to $431 million by the year 2000. From this range, a value of $247 million was selected as the most representative. Thus, water quality-related expenditures are forecast to increase from $116 million in 1975 to about $247 million in the year 2000. This is an increase of $131 million, or 113 percent, over the 1975 expenditure level, and represents about 10.6 percent of the total expenditures in the year 2000. This increase represents a per capita cost of $111 for water quality management-related items in the year 2000. It should be noted that this forecast does not take into account the outcome of the judgment and appeals pending in Federal Courts against the City of Milwaukee, the Metropolitan Sewerage Commission of the County of Milwaukee, the Sewerage Commission of the City of Milwaukee, and the Milwaukee Metropolitan Sewerage District as a result of the lawsuit brought by the State of Illinois, which could significantly affect this forecast. Table 16 presents the projected cash flow of the Metropolitan Sewerage District if the stipulated order of the court is upheld.

The table indicates an annual average expenditure commitment for the period 1977 through 1989 of $91.2 million, an amount equivalent to almost 48 percent

Table 16

ANTICIPATED EXPENDITURES BY THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT IN ACCORDANCE WITH STIPULATION MADE WITH THE STATE OF ILLINOIS

| Time Period | Expenditures Agreed to with State of Illinois[a] (in millions of constant 1976 dollars) |
|---|---|
| 1977 | $ 2.4 |
| 1978 | 26.1 |
| 1979 | 46.9 |
| 1980 | 82.4 |
| 1981 | 139.8 |
| 1982 | 187.4 |
| 1983 | 187.1 |
| 1984 | 180.5 |
| 1985 | 155.5 |
| 1986 | 86.3 |
| 1987 | 46.6 |
| 1988 | 22.5 |
| 1989 | 22.5 |
| Total | $1,186.0 |
| Annual Average | $ 91.2 |

[a] *These expenditures are based on the outcome of the initial trial and the resulting stipulated judgment order dated November 15, 1977, which were under appeal by the Metropolitan Sewerage District and thus may be altered. Cost data based on estimates current to November 15, 1977.*

*Source: Milwaukee Metropolitan Sewerage District and SEWRPC.*

of the forecast average annual water quality expenditure level of $191 million for the entire Region over the plan period. Portions of the required capital investment would be eligible for federal and state grants-in-aid which would serve to reduce the local implementation costs. In addition, the amortization costs each year—over a long-term bonding period—would be far less than the amounts committed to construction each year. It is also expected that the above-described forecast expenditures for water quality management in the Region would include the costs for a portion of the facilities needed to meet the requirements of the stipulation. Thus, if the stipulated order of the court is upheld, it is expected that the related increase in total annual water quality-related expenditures will be far less than the increase of almost 48 percent associated with the stipulation.

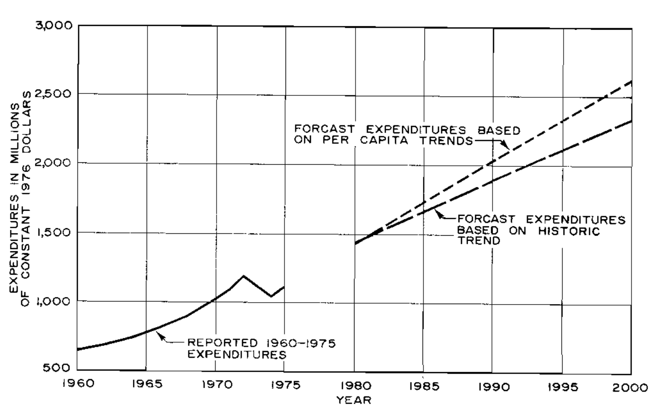
A comparison was made between the selected forecast total expenditures based on the historic expenditure trend and a total expenditure forecast based on per capita trends. As shown in Figure 9, the per capita forecast is slightly higher than the total expenditure forecast, but tends to reinforce the latter. The expenditure levels which may be expected to occur for all purposes and for water quality purposes in the Region in the year 2000 as shown in Table 17 and Figure 10, are projections based on historic trends and should be viewed, therefore, as qualified estimates of the future expenditure levels. Any legislative or economic changes which may alter the manner in which expenditures are made or the amount of expenditures made may interrupt historical trends and necessitate the development of new forecasts.

## SUMMARY

One of the very important steps necessary in the formulation of regional water quality management plans is the preparation of forecasts. Forecasts are required of all future events and conditions which are outside the scope of the plan, but which will affect plan design or implementation. In the water quality management planning process, forecasts of population, economic activity, and the demand for land are necessary to provide a basis for alternative plan evaluation and the subsequent preparation of a water quality management plan to the year 2000. The forecasts presented herein were developed by the Commission for comprehensive, areawide planning purposes, and the use of these forecasts for water quality management planning helps to assure full coordination

**Figure 9**

**REPORTED AND FORECAST TOTAL EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE REGION: 1960-2000**




*Source: SEWRPC.*

**Table 17**

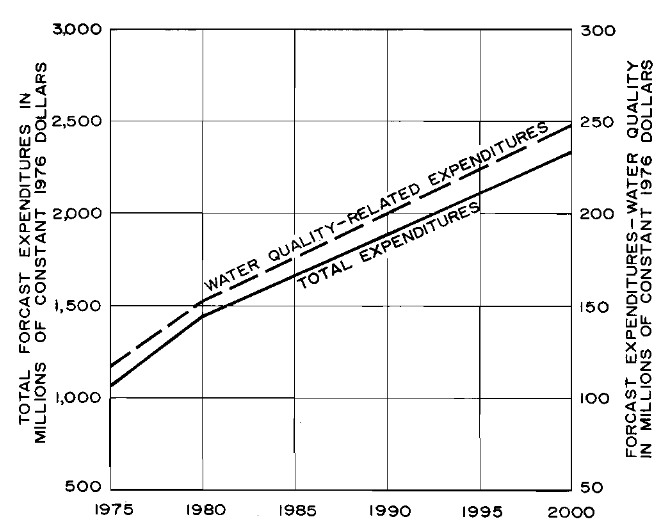
**REPORTED AND FORECAST TOTAL ANNUAL EXPENDITURES AND WATER QUALITY-RELATED EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE REGION: SELECTED YEARS 1975-2000**

| Year | Expenditures (in millions of 1976 dollars) Total | Water Quality-Related |
|---|---|---|
| 1975 | $1,120 | $115.5 |
| 1980 | $1,448 | $153.5 |
| 1990 | $1,890 | $200.3 |
| 2000 | $2,331 | $247.0 |

*Source: SEWRPC.*

**Figure 10**

**REPORTED AND FORECAST TOTAL ANNUAL EXPENDITURES AND WATER QUALITY-RELATED EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE REGION: 1975-2000**




*Source: SEWRPC.*

of such planning with regional land use, transportation, and other functional planning efforts.

The following points summarize the expected changes in regional population and economic activity levels, in land use demand, and in public financial resources by the year 2000:

1. The population of the Region may be expected to increase by approximately 463,000 persons over the 1970 population level of 1.76 million persons, Thus, the population forecast envisions a significant decline in the overall rate of population growth over the next two to three decades. The largest increase in regional population by the year 2000—62 percent—will be in the age group from 65 years of age and older. Two age groups—5-14 years of age and 15-19 years of age—are expected to decline by 8 percent and 6 percent, respectively, by the year 2000.

2. Employment in the Region is expected to reach 1,016,000 jobs by the year 2000, an increase of 237,000 jobs, or 30 percent, over the 1975 employment level of 779,000 jobs. Wholesale and retail trade and service jobs may be expected to increase at the greatest rates, ranging from 29 to 33 percent, and may be expected to provide a combined total of 614,400 jobs in the year 2000. Manufacturing employment, still the largest regional major industry employment group, may also be expected to increase by 29 percent to about 320,300 jobs in the year 2000.

3. If recent development trends continue, approximately 319 square miles of land may be expected to be converted from rural to urban uses by the year 2000. Thus, 31 percent of the Region would be devoted to urban uses by the year 2000 compared to 19 percent in 1970. If this projected land use demand is met entirely through the conversion of rural to urban land use, the overall density of the developed area of the Region would decline from 4,350 persons per square mile in 1970 to 2,300 persons per square mile in the year 2000.

4. Local government expenditures in the Region are expected to increase by 108 percent—from $1,120 million in 1975 to $2,330 million in the year 2000. About 10.6 percent, or $247 million of this total expenditure level, is expected to be spent on water quality management-related items. This is an increase of $131 million, or 113 percent, over the 1975 water quality-related expenditure level, and represents a per capita cost of $111 for water quality management-related items in the year 2000.

It is evident from the forecasts summarized above that the Region in the year 2000 will be quite different from the Region as we know it today. Succeeding chapters in this report present alternative water quality management plans designed to abate pollution and meet established water use objectives in the face of these anticipated changes, and to preserve and protect the limited and irreplaceable natural resources of the Region.

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# Chapter IV

# ALTERNATIVE PLANS

## INTRODUCTION

The essence of planning is the generation and assessment of alternative means of achieving agreed-upon objectives. Information presented in Volume One of this report concerning related regional planning programs, basic planning concepts, the natural and man-made features of the Region, the sources of water pollution, water quality conditions and trends, and legal and financial considerations, and in the previous chapter of this volume concerning anticipated growth and change, provides the basis for the development and analysis of alternative water quality management measures for southeastern Wisconsin. The cardinal objective of the regional water quality management planning program is to develop cost-effective plans for, and thereby assist in, the abatement of water pollution problems and the attainment of levels of water quality in the Region which are consistent with established water use objectives. This chapter is intended to present and analyze alternative water quality management measures to achieve the agreed-upon water use objectives and supporting water quality standards for the lakes and streams to the year 2000 through the most practical and cost-effective actions for the abatement of both point and nonpoint sources of pollution.

In the control of point sources of pollution, alternative combinations of physical arrangements—or systems—of sewerage facilities and of attendant levels of wastewater treatment can be readily postulated utilizing well-established engineering practices, all of which will achieve specified water use objectives and supporting water quality standards, and which differ only in cost. Such arrangements, therefore, constitute a true set of alternatives from which the best or most cost-effective alternative can be selected for adoption and implementation. To achieve the recommended water use objectives and supporting water quality standards for the inland lakes and streams of southeastern Wisconsin, however, it will be also necessary to deal with a quite different kind of pollution source—that of runoff from both rural and urban land. The task of formulating alternatives for the abatement of this diffuse, nonpoint source of pollution requires an approach somewhat different from that for the abatement of point sources of pollution. There do exist different physical measures for nonpoint source abatement; and combinations of these measures, and of the geographic application of these measures, can be developed. The development of site-specific rural land management practices, however, requires detailed consideration of a great many factors including not only soils, slopes, land use, microclimate, subsurface characteristics, and existing management practices, but the historic management practices, property ownership, owner-operator objectives and preferences, available land management equipment, investment policies, available technical and financial resources, and methods by which public agencies seek plan implementation. Similarly, the complex and intensive use of urban lands, and the still developing state-of-the-art of the control of pollution from urban storm water runoff, preclude the identification of site-specific practices in a systems-level water quality management plan. The complexity of both rural and urban nonpoint source abatement, as a practical matter, dictates that at the areawide, systems level of planning, the plans be limited to an identification of the extent and severity of the pollution sources and the attendant need for the development of specific control measures through local facilities or project level planning.

Inland lakes represent a particularly difficult problem in this respect. The pollutant-sensitive nature of the major inland lakes within the Region often requires application of a high level of nonpoint source abatement. Many management measures already undertaken on a routine basis to maintain the lakes in good condition for recreational and fishery use and to enhance their aesthetic appeal are often of a cosmetic nature and do not result in any long-term improvements of the lake water quality. Specifically, short-term measures such as weed and algae control programs, fish stocking programs, and litter clean-up efforts are commonly conducted for lakes in the Region, but do not result in significant long-term improvements in water quality conditions. Because of the value of these measures to the use of the lakes, and of the importance of concurrently applying more effective long-term control measures, the plan elements presented herein for the 100 major inland lakes in the Region are not true alternatives in the sense of each being capable of achieving the same objectives by different means. Instead, they are potential management actions which will improve lake water quality conditions effectively, and to a level which will slow the rate of water quality degradation or maintain or enhance, as needed, the existing lake water quality conditions.

In the consideration of the abatement measures presented in this chapter, the iterative nature of the water quality management planning process must be recognized. This process consists of successive cycles of areawide systems planning and local project planning efforts, with each cycle of local project planning serving to refine and detail preceding cycles of systems planning and each cycle of systems planning building upon preceding cycles of project planning, incorporating the refinements and details of local implementation actions. The recommendations of the adopted regional sanitary sewerage system plan, and the resulting development of detailed local facilities plans, represent this kind of planning cycle. Accordingly, this chapter presents alternative proposals for point source abatement measures only where changes since adoption of the regional sanitary sewerage system plan indicate the need to reconsider such alternatives at the systems level. Although sewerage facilities planning has historically provided a good example of the cyclical nature of the planning process, the implementation of nonpoint pollution source controls can be expected to provide an even more dramatic example, as local knowledge, community preferences, changing social and economic conditions, and continuing research influence the implementation of areawide systems planning recommendations for water pollution abatement. Alternative proposals for the nonpoint source abatement measures are presented which complement the recommended point source abatement measures.

## RELATIONSHIP TO REGIONAL SANITARY SEWERAGE SYSTEM PLAN RECOMMENDATIONS

The regional sanitary sewerage system plan recommendations were many and varied and all related in one way or another to the attainment of areawide water quality management objectives. For the purposes of this chapter these recommendations can be considered in three categories. First, there are those recommendations which remain sound and valid as indicated by a review of the regional sanitary sewerage system plan during facilities planning efforts completed subsequent to adoption of the system plan. Within this category fall the majority of the recommendations of the sewerage system plan. The systems level recommendations of the adopted regional sanitary sewerage system plan for joint sewage treatment plants for portions of the Milwaukee Metropolitan subregional area are particularly important in this respect and are proposed to be incorporated into the areawide water quality management plan without change in the number and location of treatment plants.

These portions include the Milwaukee Metropolitan Sewerage District service area with abandonment recommended for the sewage treatment plants at Menomonee Falls, Hales Corners, and Caddy Vista; the Kenosha-Racine subregional area, with major treatment facilities to be operated by the Cities of Kenosha and Racine; the Upper Fox River subregional area, with major treatment facilities to be operated by the Cities of Brookfield and Waukesha; the portion of the lower Fox River subregional area proposed to be served by the major facilities to be operated by the Western Racine County Sewerage District and the Town of Norway Sanitary District No. 1; the portions of the Middle Rock River subregional area proposed to be served by the major facilities to be operated by the City of Oconomowoc and the Delafield-Hartland Water Pollution Control Commission; and the portion of the lower Rock River subregional area to be served by the Walworth County Metropolitan Sewerage District. In addition, most of the recommendations of the regional sanitary sewerage system plan regarding sewerage facilities which did not involve detailed consideration of joint treatment and interconnection of municipal sewerage systems were generally incorporated into the areawide plan without change.

A second set of recommendations are those regarding the location and number of treatment facilities which are to be reevaluated in various local facilities planning programs in the Region, with particular emphasis on the configuration of the major sewerage facilities. More specifically, local facilities planning programs will address the system configurations for the proposed sewer service area encompassing the City of Lake Geneva, the Villages of Williams Bay, Fontana-on-Geneva Lake, and Walworth, and portions of the Towns of Geneva, Lyons, Linn, and Walworth; for the sewer service area encompassing the Village of Darien and environs, with respect to possible interconnection with the Walworth County Metropolitan Sewerage District facilities; for the sewer service area encompassed by the Town of Salem Sanitary District No. 2; for the sewer service area encompassing the City of Cedarburg, the Village of Grafton, and portions of the Towns of Cedarburg and Grafton; for the existing satellite sewage treatment plants at Thiensville, Germantown, New Berlin, Muskego, and Franklin in the Milwaukee Metropolitan Sewerage District service area; and for portions of the Kenosha-Racine subregional area. All of the local facilities planning efforts involving the facilities in this second category are presently underway.

The third set of recommendations are those which were reevaluated under the areawide water quality management planning program. Included in this set are the recommendations regarding the number and location of all public wastewater treatment facilities in the Des Plaines River and Root River Canal subregional areas, in the West Bend and Tri Lakes sewer service area in the upper Milwaukee subregional area, and in the Hartford and Pike Lake sewer service areas in the upper Rock River subregional area; the evaluation of land application of effluent; the need for advanced waste treatment at certain wastewater treatment facilities in the Region; and the evaluation of the use of privately owned onsite sewage disposal systems to serve isolated enclaves of urban development. In addition, the degree of treatment and the effluent characteristics of all of the point source discharges have been reevaluated considering the established water use objectives and surface water quality assessments conducted under the areawide water quality management planning program.

## PLAN DESIGN

The alternative water quality management plans presented in this chapter are all based on the new year 2000 regional land use plan prepared and adopted by the Commission in 1977 and on the regional sanitary sewerage system plan,[1] prepared and adopted by the Com-

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[1] *SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, April 1975, and Volume Two, Alternative and Recommended Plans, May 1978; and SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.*

mission in 1974. With respect to the regional sanitary sewerage system plan, however, the alternatives presented herein reflect the revised population, economic activity, and land use forecasts set forth in the new regional land use plan; the refinement and detailing of the sewerage system plan resulting from the facilities planning efforts completed within the Region since 1974; the findings of the regional sludge management systems planning program; the Commission inventories of all known existing sources of water pollution in the Region; the current stream and lake water quality conditions and historic trends in those conditions; the Commission inventory of the state-of-the-art of water pollution control;[2] and the Commission hydrologic-hydraulic water quality simulation data, which provide forecasts of probable future and existing stream and lake water quality conditions, as well as calculations of the levels of pollution abatement necessary to satisfy applicable water use objectives and supporting water quality standards. The process by which alternative point, nonpoint, and sludge management plans were formulated included:

1. Determination of the appropriate geographical units for analysis of point source control, sludge handling and utilization, and nonpoint source control;

2. Identification of year 2000 population and economic activity levels, land uses, sewer service areas, and municipal and industrial wastewater flows;

3. Estimation of the extent and severity of existing and anticipated water quality problems;

4. Identification and testing—in logical sequence—of various water pollution control measures including various levels of wastewater treatment and land management; and

5. Estimation of costs of control measures.

These procedural explanations are followed by a discussion for each of the 12 major watersheds of: existing and probable future sources of pollution and existing and probable future water quality conditions under alternative pollution control actions. Recommended diffuse source control measures necessary to achieve the water use objectives and supporting standards for the streams and major inland lakes are discussed in Appendix C of this volume and were developed as an integral part of the nonpoint source abatement plan element design process. The chapter itself concludes with a discussion of point source abatement measures by subregional area.

Determination of Geographic Units

Water quality is affected by many factors which are measured, controlled, estimated, forecast, or managed according to different geographic jurisdictions. The underlying population and economic activity level forecasts are made at the regional and county level and then allocated, in accordance with regional and local land use development objectives, to various combinations of subregional civil divisions. The actual control of land use development to influence population and economic growth in accordance with the land use development objectives is exercised at the county and local municipal levels. Control of urban storm drainage is organized by hydrologic drainage basin within civil divisions. Urban land management practices may be executed by county, city, village, town, or individual land owners. Rural land management practices are executed by individual land owners and are influenced by land ownership patterns, the type of farming enterprise and the economics related thereto, topography, and soil type. Sanitary sewerage systems are maintained and operated according to subregional areas, which often cross hydrologic watershed boundaries. Thus, the skillful selection of proper geographic planning units is essential to the development of sound pollution control plans.

The Commission, as part of its regional sanitary sewerage system planning program, delineated geographic subareas of the Region which comprised rational sewerage system planning areas. The boundaries of these 11 areas were delineated according to major natural watershed divides, the exterior boundaries of the Region, the existing and potential service areas of existing centralized sanitary sewerage systems, and existing and probable future areas of urban development. The 11 subregional areas are described later in this chapter under the discussion on the point source element of the water quality management plan. Because of their use for sewerage system planning, these areas provided the best available basis for organizing the sanitary sewerage system inventory and the analyses of point source alternative plan elements required for the areawide water quality management planning effort. It was necessary, however, to refine the results of these analyses and to relate them to the watersheds to which the treated effluents are discharged. This chapter relates by subregional area the point pollution sources, relying on the analyses by watershed to determine the relationship between point and nonpoint sources of pollution and the degree of pollutant control within a receiving watershed.

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[2]*SEWRPC Planning Report No. 29, A Regional Wastewater Sludge Management Plan for Southeastern Wisconsin, July 1978; SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, September 1978; SEWRPC Technical Report No. 17, Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975, June 1978; and SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume One, Point Sources, July 1977, Volume Two, Sludge Management, August 1977, Volume Three, Urban Storm Water Runoff, July 1977, and Volume Four, Rural Storm Water Runoff, December 1976.*

Once the intelligent delineation of analytical areas had been completed, and point source recommendations had been developed, the analysis of sludge management alternatives was conducted. Clearly, each individual site of sludge generation provides unique locational and volumetric—and even quality—information essential to the development of areawide alternatives. However, knowledge of existing practices indicated extensive overlap—and therefore, potential interaction—among the physical areas within which sludge management occurs. Accordingly, the Commission analyzed individually or categorically the sludge management alternatives for the individual treatment plants, but did so in a regional context, testing geographic alternatives ranging in concept from a single, regional system to a set of independent local systems. The results of all such analyses are reported according to the individual treatment facilities, along with detailed documentation of the analyses, in SEWRPC Planning Report No. 29, A Regional Wastewater Sludge Management Plan for Southeastern Wisconsin.

Nonpoint sources of water pollution are activated, and the pollutants transported largely, by hydrologic processes. Therefore, the evaluation and resolution of such pollution sources are best accomplished according to hydrologic drainage area: 12 major inland watersheds and subwatersheds thereof. Therefore, wherever appropriate, the hydrologic drainage areas were further disaggregated into smaller drainage areas in the water quality management plan for the quantification of problems, practices, or costs. The analysis of control measures to protect lake water quality represents an example of a situation requiring the identification of a smaller geographic unit. Because the basis for analyses were hydrologic units, the quantification of water quality problems and plan recommendations sometimes divided urban development areas. An example would be the estimation and apportionment of pollution control costs if the portion of an urban area within one subwatershed required higher levels of nonpoint source abatement than did the remaining portion of the urban area located within another subwatershed. Proper apportionment of estimated costs here would require distinction between the two subwatersheds within the urban area.

### Identification of Future Populations, Land Use, and Sanitary Sewer Service Areas

The sewer service areas were developed within the broader context of the comprehensive, long-range planning programs of the Commission. The population and economic activity level forecasts, as discussed in Chapter III of this volume, and the implications of these forecasts for land use, are fundamental to the forecasting of point source wastewater discharge loads and storm water runoff amounts and characteristics.

The Regional Planning Commission, after careful consideration of four significantly different alternative land use plans—a corridor plan, a satellite city plan, a controlled existing trends plan, and an uncontrolled existing trends plan—in 1966 adopted a regional land use plan for the design year 1990.[3] Under its continuing land use planning program, the Commission in 1972 undertook a major reevaluation and revision of that plan, based in part upon implementation achieved since original plan adoption. In that reevaluation and revision, two alternative land use plans were considered for the Southeastern Wisconsin Region for the design year 2000: a controlled centralization plan and a controlled decentralization plan.[4] The controlled centralization plan alternative, as the name indicates, seeks to promote a more centralized pattern of urban development in the Region, with virtually all new urban development occurring at medium density, in planned neighborhood units, and in areas of the Region which can be readily provided with such important urban facilities and services as centralized public sanitary sewer, public water supply, and mass transit. In contrast, the controlled decentralization plan alternative emphasizes lower density and more diffused residential development and the use of onsite soil absorption sewage disposal (septic tank) systems and private water supply wells. Based upon a careful evaluation of these two land use plan alternatives against adopted regional land use development objectives and standards, the recommendations of the technical and citizens advisory committees concerned, and a review of the results of a series of public informational meetings and public hearings concerning the land use plan alternatives held throughout the Region in July of 1976 and in November and December of 1977, the Commission acted to adopt the controlled centralization plan alternatives as the new regional land use plan for the year 2000. The controlled centralization plan, refined to incorporate the suggestions of interested citizen leaders and local planners and engineers and to reflect detailed community development proposals, is shown in graphic summary form on Map 2.

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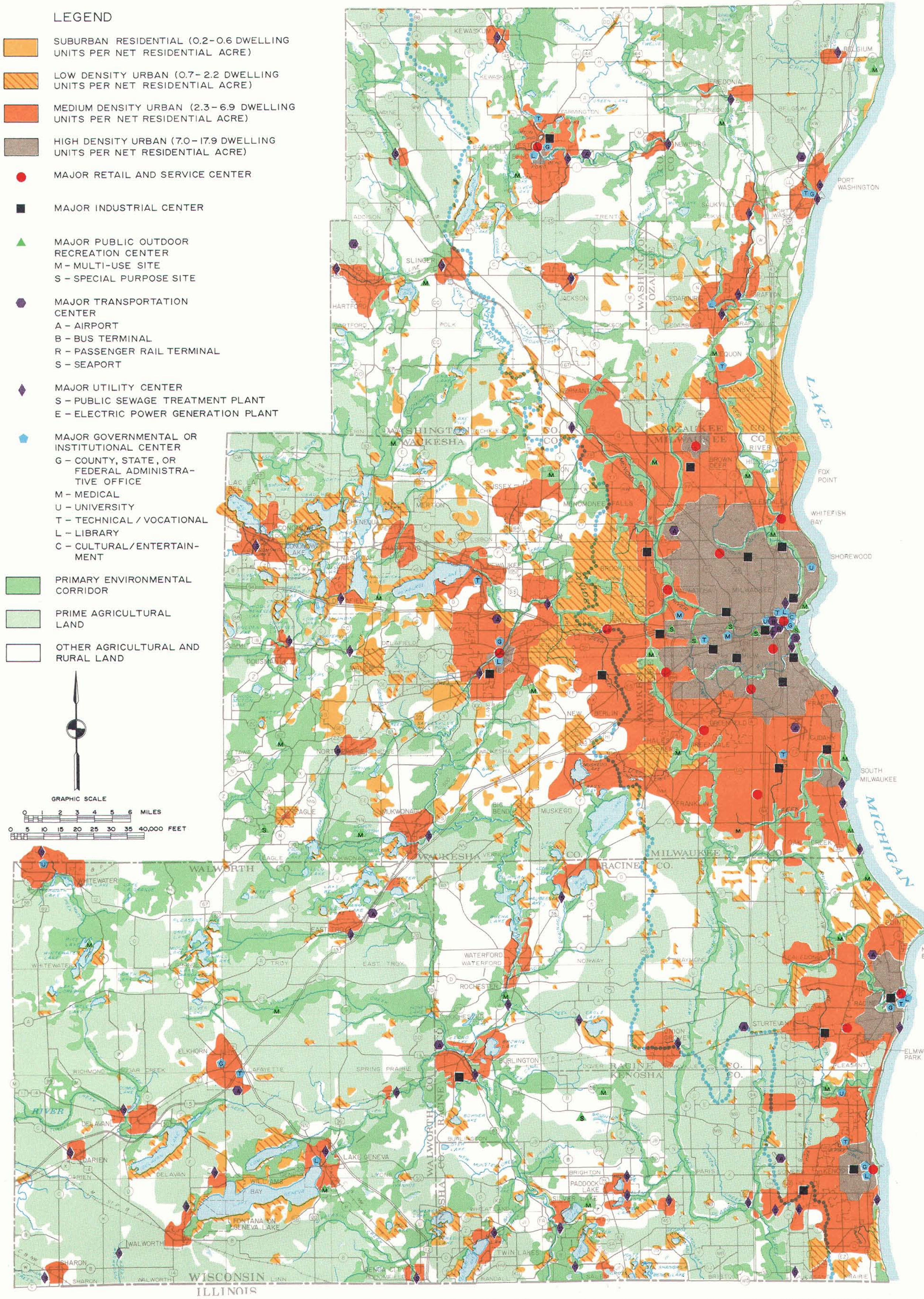
[3] *See SEWRPC Planning Report No. 7, The Regional Land Use-Transportation Study, Volume One, Inventory Findings: 1963, May 1965, Volume Two, Forecasts and Alternative Plans: 1990, October 1966, and Volume Three, Recommended Regional Land Use-Transportation Plans: 1990, November 1966.*

[4] *See SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume One, Inventory Findings, April 1975, and Volume Two, Alternative and Recommended Plans, May 1978.*

Map 2

## ADOPTED LAND USE PLAN FOR THE SOUTHEASTERN WISCONSIN REGION: 2000




The recommended regional land use plan envisions converting about 113 square miles of land from rural to urban use over the period 1970 to 2000 to accommodate the forecast 463,000-person increase in the regional population expected over this time period. The degree of centralization of the recommended plan is indicated by the fact that more than 60 percent of all new urban residential land and about 49 percent of the incremental resident population would be located within 20 miles of the central business district of the City of Milwaukee. Even with this emphasis on centralization of land use development, the average population density of the developed urban area of the Region would decline from about 4,350 persons per square mile in 1970 to about 3,500 persons per square mile in the year 2000.

*Source: SEWRPC.*

The basic concepts underlying the recommended land use plan for the year 2000 are the same as those underlying the regional land use plan for 1990. Like the adopted year 1990 regional land use plan, the recommended land use plan for the year 2000 recognizes the importance of the urban land market in determining the location, intensity, and character of future urban development. The plan, however, proposes to regulate to a greater degree than in the past the effect of this market on development in order to ensure that new urban development occurs at densities consistent with the provision of public centralized sanitary sewer, water supply, and mass transit facilities and services and in locations where such facilities can be readily and economically extended or obtained. In so doing, the plan seeks to provide a more orderly and economic development pattern and to abate areawide developmental and environmental problems within the Region, thereby channeling the results of market forces into better conformance with the established regional development objectives.

As with the adopted year 1990 regional land use plan, historic growth trends within the Region under the recommended plan for the year 2000 would be altered because intensive urban development would occur only in those areas of the Region having soils suitable for such development and which may be readily provided with sanitary sewer, public water supply, mass transit, and other essential urban services, and which are not subject to special hazards such as flooding.

For a description of the specific procedures utilized in preparing the recommended regional land use plan for the year 2000, and for a more complete description of the plan, see SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative and Recommended Plans. The new regional land use plan, being the product of a second cycle of areawide systems planning, reflects the sanitary sewer service areas proposed in the adopted regional sanitary sewerage system plan and subsequent facilities planning efforts. The new regional land use plan thus provides a sound basis for the preparation of the alternative areawide water quality management plans presented in this chapter.

The importance of a sound land use plan to the control of point sources of pollution is relatively well recognized, since the location, confirmation, and sizing of the physical elements of sanitary sewerage systems are directly affected by the type, location, and extent of urban land development. However, the importance of such a plan to nonpoint pollution control has only begun to be appreciated. As demonstrated on Maps 3 and 4, respectively, the management of existing agricultural lands for livestock production and for soil erosion control is affected by the potential of such land for transition to urban land uses or the property owner's perception of that potential. The willingness of land owners to install soil and water conservation practices is reduced if they perceive their land to be subject to conversion from rural to urban use. The land use plan serves to identify and distinguish between areas which should remain permanently in rural use and areas in which urban development can be expected to occur.

Sewage flows estimates based on forecast as well as existing population and economic activity levels and land use were forecast for use in the development of areawide water quality management plans as described in the following sections.

### Point Source Control Design Criteria

A major finding of the areawide water quality management planning program is that continued abatement of point source pollution will be needed to meet established water use objectives and supporting standards within the Region. The development of the point source element of the water quality plan required determination of the most cost-effective means of providing the necessary level of control. The engineering design critieria and analytic procedures utilized to design, test, and evaluate the alternative point source abatement plans were revised versions of the criteria and procedures utilized in the preparation of the regional sanitary sewerage system plan, the revisions being based upon the findings of state-of-the-art studies conducted under the areawide water quality management planning program.

The character as well as the quantity of sewage are particularly important considerations in the design of point source pollution abatement alternatives. Consequently, under the areawide water quality management planning program, the design criteria utilized for estimating wastewater flow and characteristics under the regional sanitary sewerage system plan were carefully reviewed. In addition, alternative control measures developed under the state-of-the-art studies were incorporated as necessary into the alternative design, test, and evaluation of point source pollutant control alternatives.

Sewage Flow: Sewage flow consists basically of domestic, commercial, and industrial wastewater; storm water inflow; and groundwater infiltration. One of the most important criteria used in the design of sewers is the amount of sewage flow contributed from the land uses within the drainage areas tributary to a given sewer. Normally, sewage flow is estimated in gallons per capita per day (gpcd) or cubic feet per second per acre (cfs/acre). Several sets of design criteria have been used within the Region to estimate wastewater flow, including those formulated under the Commission's Fox and Milwaukee River watershed studies; those utilized by the Milwaukee-Metropolitan Sewerage Commissions; those contained in the Recommended Standards for Sewage Works,[5] popularly called the "Ten-States Standards"; those included in the Rules of the Wisconsin Department of Natural Resources; and those utilized in the development of the regional sanitary sewerage system plan. Each of these sets of wastewater design flow criteria is discussed below.

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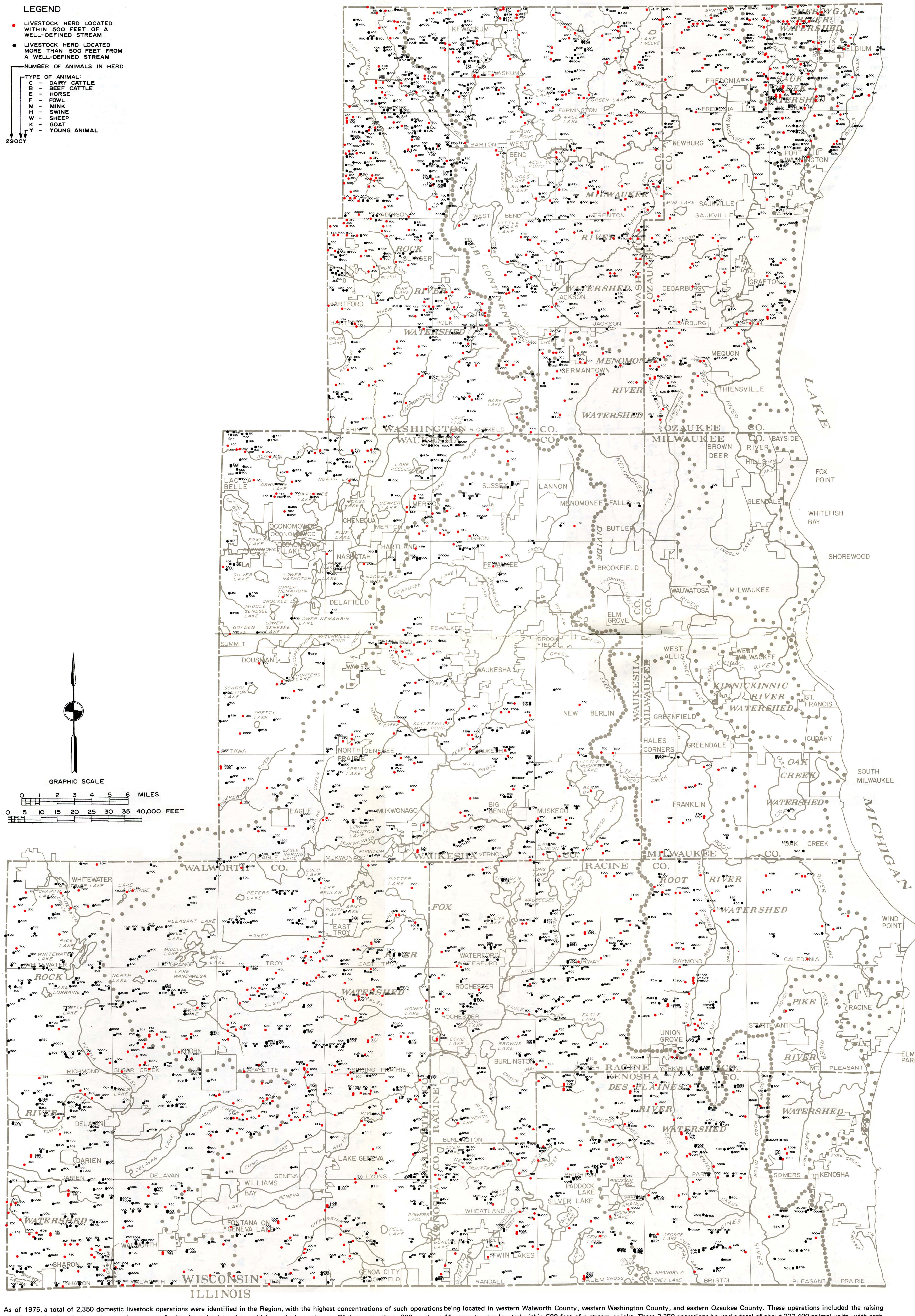
[5] *Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, Recommended Standards for Sewage Works, Public Health Education Service, Revised Edition, 1973.*

Map 3

**DISTRIBUTION OF LIVESTOCK OPERATIONS IN THE REGION AND THEIR RELATIONSHIP TO URBAN LAND USES: 1975**

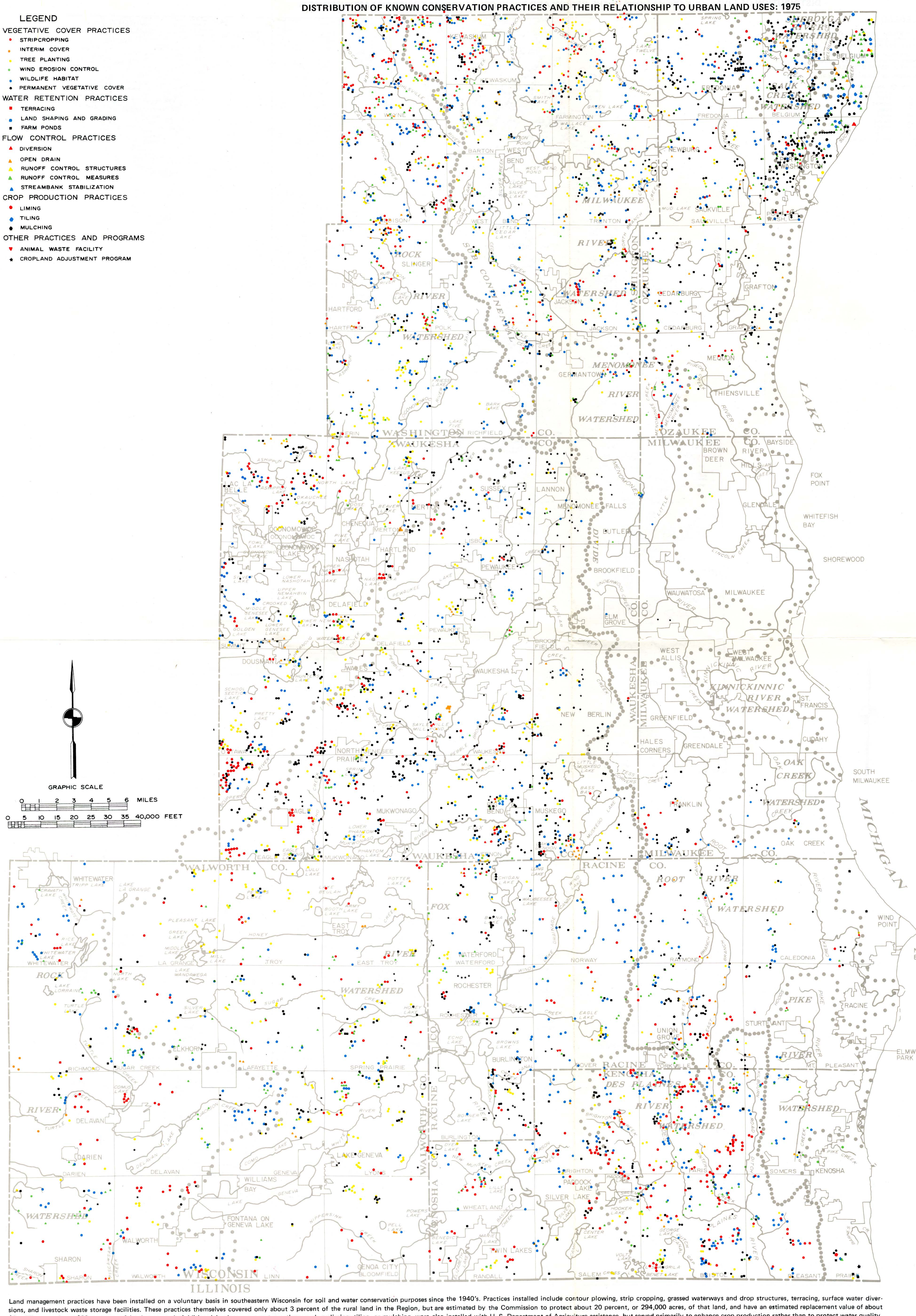



As of 1975, a total of 2,350 domestic livestock operations were identified in the Region, with the highest concentrations of such operations being located in western Walworth County, western Washington County, and eastern Ozaukee County. These operations included the raising of dairy and beef cattle, hogs, horses, sheep, goats, fur-bearing animals, turkeys, chickens, ducks, and geese. Of these operations, 963, or about 41 percent, were located within 500 feet of a stream or lake. These 2,350 operations housed a total of about 227,400 animal units—with each unit being equivalent in waste production to a 1,000 pound cow. The wastes generated by these operations are equivalent to the raw wastes generated by about two million persons. The spatial distribution of these operations reflect the extent to which speculation in land for urban use has proceeded in the Region, with relatively fewer operations being located in areas locally envisioned as available for conversion to urban use. This pattern of reduced livestock concentrations is generally matched by the relatively greater concentrations of cash crops found in such areas of potential urbanization.

*Source: U. S. Department of Agriculture, Soil Conservation Service and Agricultural Stabilization and Conservation Service; County Soil and Water Conservation Districts; University of Wisconsin Extension Service; and SEWRPC.*

## Map 4

### DISTRIBUTION OF KNOWN CONSERVATION PRACTICES AND THEIR RELATIONSHIP TO URBAN LAND USES: 1975




Land management practices have been installed on a voluntary basis in southeastern Wisconsin for soil and water conservation purposes since the 1940's. Practices installed include contour plowing, strip cropping, grassed waterways and drop structures, terracing, surface water diversions, and livestock waste storage facilities. These practices themselves covered only about 3 percent of the rural land in the Region, but are estimated by the Commission to protect about 20 percent, or 294,000 acres, of that land, and have an estimated replacement value of about $6 million, or about $20 per acre of land protected. Additional land management practices, such as liming, tiling, or mulching, were also installed with U. S. Department of Agriculture assistance, but served primarily to enhance crop production rather than to protect water quality. The spatial distribution of the practices above indicates that land management is affected by the potential for transition from rural to urban land uses, with relatively few land management practices installed in the agricultural lands near existing urban areas. The highest densities of conservation practices were noted in the northern half of Washington County and the east-central portion of Ozaukee County. The practices also tend to occur in clusters. This reflects the effects of a voluntary program relying on contact between neighbors, and the creation of communities of interest in good soil and water conservation.

*Source: U. S. Department of Agriculture, Soil Conservation Service and Agricultural Stabilization and Conservation Service; and SEWRPC.*

In both the Fox and Milwaukee River watershed studies, design sewage flows were based on relationships between population size and average daily sewage flow established from empirical data collected from communities of varying size throughout the two watersheds. In the Fox River watershed study, design sewage flows were based on an average daily flow contribution of 120 gpcd in communities with populations of less than 5,000, and an average flow contribution of 180 gpcd in communities with 5,000 or more population. Trunk sewers were sized on a peak-to-average flow ratio of 2 to 1, resulting in design flows of 240 gpcd and 360 gpcd for the smaller and larger communities, respectively. The average daily and peak design sewage flows were assumed to include normal storm water inflow and groundwater infiltration, as well as domestic, commercial, and industrial wastewater flows.

In the Milwaukee River watershed study, average daily design sewage flows were based on a contribution which varied from 120 gpcd for communities with less than 1,000 population to 210 gpcd for communities of more than 30,000 population. Trunk sewers were sized on a peak-to-average flow ratio of 2 to 1, resulting in peak design flows ranging from 240 gpcd to 420 gpcd. As in the Fox River watershed study, the average daily and peak design flows were assumed to include normal storm water inflow and groundwater infiltration, as well as domestic and industrial wastewater flows.

The rules of the Milwaukee-Metropolitan Sewerage Commissions specify that sanitary sewers built by municipalities and connected to the Sewerage Commission's trunk or interceptor sewers be sized on the basis of a peak flow contribution of 0.015 cfs/acre in areas where the population ranges from 10 to 14 persons per gross residential acre, and on the basis of a contribution of 0.020 cfs/acre in areas where the population ranges from 15 to 20 persons per gross residential acre. These design flow rates are equivalent to a peak contribution ranging from 650 gpcd to 970 gpcd, and include allowances for storm water inflow and groundwater infiltration. Where the population is less than 10 or more than 20 persons per gross residential acre, special studies are required to determine the peak design flow criteria to be used.

Trunk and interceptor sewers under the jurisdiction of the Milwaukee-Metropolitan Sewerage Commissions are designed on the basis of a 450 gpcd instantaneous peak flow.

The Ten-States Standards recommend that sanitary sewers be sized using a minimum average daily design flow of 100 gpcd and a peak design flow of at least 250 gpcd. Design criteria used in the Fox and Milwaukee River watershed studies closely approximate the Ten-States Standards recommendations. The Rules of the Department of Natural Resources set forth sanitary sewer sizing procedures similar to those included in the Ten-States Standards.

In the regional sanitary sewerage system planning program, criteria were developed relating average daily and instantaneous peak sewage flows to the major land use categories identified in the adopted regional land use plan. Criteria were also developed pertaining to allowances for normal groundwater infiltration and storm water inflow. Based upon an analysis of wastewater treatment plant flow and water supply system pumpage records for selected communities throughout the Region, it was determined that an average daily sewage flow contribution of 125 gpcd would be utilized in the regional study for sizing sewerage system components. This base flow was intended to include all domestic, commercial, and industrial sewage contributions exclusive of storm water inflow or groundwater infiltration. This per capita base flow was then used in combination with groundwater infiltration and storm water inflow allowances to develop design sewage flows based upon distribution of the forecast population at a medium density defined as 10.2 persons per gross acre. It was determined that a variable peak-to-average ratio for sanitary sewage, excluding infiltration and storm water inflow, would be utilized to design trunk sewers, with the ratio varying from a low of 2.5 to 1 to a high of 5.0 to 1, depending upon the population of the service area tributary to the given sewer. The trunk sewer design criteria selected for use in the regional sanitary sewerage system plan are summarized in Table 18 and are discussed in more detail in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin: 1974.

Under the areawide water quality management planning program, available hydraulic loading information was obtained for each municipal sanitary sewerage system. Data on the specific components of the wastewater flow were analyzed and compared to the data obtained under the regional sanitary sewerage system plan which had been developed based upon seven selected communities in the Region. Based upon an analysis of wastewater treatment plant flow, water supply system pumpage records, and local facilities planning documents, the average daily sewage flow contributions for domestic, commercial, and industrial sources within the Region were estimated. These data are summarized in Table 19 and are included in detail in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Analysis of the data utilized to develop Table 19 indicates that, in general, there is a significantly higher per capita contribution of wastewater in the communities of the Region with higher populations due principally to higher industrial wastewater contributions. It has been concluded that sewer sizing for developing areas under the areawide water quality management plan should be based upon areas which, in general, do not exhibit the larger industrial wastewater flow contributions exhibited in the present wastewater contributions of the larger, more industrialized cities in the Region. The regional average of 121 gpcd based upon an average of all of

Table 18

CRITERIA FOR TRUNK SEWER DESIGN FLOWS UTILIZED IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLAN AND INCORPORATED INTO THE AREAWIDE WATER QUALITY MANAGEMENT PLANNING PROGRAM

| Sanitary Sewer Service Area | | Sanitary Sewage | | | | Infiltration[b] | | Storm Water Inflow[b] | |
|---|---|---|---|---|---|---|---|---|---|
| 1990 Population | Implicit Size[a] (acres) | Average Daily Contribution (gpcd) | Peak-to-Average Ratio | Peak Daily Contribution (gpcd) | Percent of Total Instantaneous Peak Flow | Average Daily Contribution (gpcd) | Percent of Total Instantaneous Peak Flow | Average Daily Contribution (gpcd) | Percent of Total Instantaneous Peak Flow |
| 0- 2,000 | 0- 196 | 125 | 5 | 625 | 78.6 | 85 | 10.7 | 85 | 10.7 |
| 2,000-10,000 | 196- 982 | 125 | 4 | 500 | 74.6 | 85 | 12.7 | 85 | 12.7 |
| 10,000-20,000 | 982-1,960 | 125 | 3 | 375 | 68.8 | 85 | 15.6 | 85 | 15.6 |
| 20,000+ | 1,960+ | 125 | 2.5 | 313 | 64.8 | 85 | 17.6 | 85 | 17.6 |

| Sanitary Sewer Service Area | | Total Instantaneous Peak Flow (in equivalent units) | | | | | |
|---|---|---|---|---|---|---|---|
| 1990 Population | Implicit Size[a] (acres) | Gallons per Capita per Day | Percent of Total | Million Gallons per Day | Gallons per Acre per Day | Cubic Feet per Second | Cubic Feet per Second per Acre |
| 0- 2,000 | 0- 196 | 795 | 100.0 | 0- 1.59 | 8,120 | 0- 2.46 | 0.0126 |
| 2,000-10,000 | 196- 982 | 670 | 100.0 | 1.34- 6.70 | 6,830 | 2.08-10.40 | 0.0106 |
| 10,000-20,000 | 982-1,960 | 545 | 100.0 | 5.45-10.90 | 5,550 | 8.45-16.90 | 0.00860 |
| 20,000+ | 1,960+ | 483 | 100.0 | 9.67+ | 4,930 | 15.0+ | 0.00765 |

[a] *All sanitary service areas were assumed to be composed of medium-density urban land uses with 10.2 persons per gross acre. The size, in acres, of the sanitary sewer service area resulting from this assumption is obtained by dividing the population served by 10.2 people per gross acre.*

[b] *In the development of the regional sanitary sewerage system plan design criteria, the infiltration rate and the storm water inflow rate for medium-density residential land use were each 0.6 gallons per minute (gpm) per acre of residential area served. Since population density is assumed to be 10.2 people per gross acre, infiltration and storm water inflow may each be expressed on a per capita basis as 85 gallons per capita per day (gpcd).*

*Source: SEWRPC.*

the individual community treatment plant per capita contributions would not be significantly weighted by the larger per capita contributions of the industrialized cities. Thus, an average daily flow contribution of 125 gpcd can realistically be utilized in the areawide water quality management plan for sizing sewerage system components in most areas. This is the same value as utilized in the regional sanitary sewerage system plan and closely approximates the regional average value of 121 gpcd indicated in Table 19 when the average is not weighted to reflect the population of the sewered community.

It was determined that a variable peak-to-average ratio for sanitary sewage, excluding infiltration and storm water inflow, would be utilized to design trunk sewers, with the ratio varying from a low of 2.5 to 1 to a high of 5.0 to 1, depending upon the population of the service area tributary to the given sewer. Table 20 presents the peak-to-average daily flow ratios adapted from data presented in ASCE Manual of Engineering Practice No. 37, Design and Construction of Sanitary and Storm Sewers, utilized in the areawide water quality management and planning program and previously utilized in the regional sanitary sewerage system planning program. Where minimum flow velocities required investigation, the ratio of average daily to minimum flow was assumed to be the same as the ratio of peak flow to average daily flow.

As previously noted, in addition to allowing for wastewater flow from residential, commercial, institutional, and industrial land uses, allowances were made in the design criteria for storm water inflow and groundwater infiltration. An analysis of the existing sewer system infiltration and inflow rates experienced in the Region was conducted under the areawide water quality management and planning program. Results of that analysis are reported in detail in SEWRPC Technical Report No. 21. The regional per capita infiltration rate calculated as the average of the individual infiltration rates experienced in the sanitary sewerage systems of the Region was 84 gpcd, or about 0.59 gallons per minute (gpm) per acre. Average

Table 19

SANITARY SEWAGE FLOW COMPONENT SUMMARY

| Component[a] | Range of Average per Capita Contribution (gpd) | Average per Capita Contribution Not Weighted by the Population of the Tributary Area[b] (gpd) | Average per Capita Contribution Weighted by the Population of the Tributary Area[c] (gpd) |
|---|---|---|---|
| Domestic . . . . . . | 47 - 133 | 89 | 108 |
| Commercial . . . . | 0 - 36 | 16 | 20 |
| Industrial . . . . . . | 0 - 95 | 16 | 65 |
| Total | 47 - 264 | 121 | 193 |

[a] *Includes all domestic, commercial, and industrial sewage contributions exclusive of storm water inflow or groundwater infiltration.*

[b] *Average is calculated as the mean value of the individual community per capita values included in Appendices D and E of SEWRPC Technical Report No. 21.*

[c] *Average is calculated as the total daily contribution within the Region divided by the contributing population. This value is notably influenced by the contributions in the larger communities such as the Cities of Milwaukee, Racine, and Kenosha.*

*Source: SEWRPC.*

Table 20

RATIO OF PEAK FLOW TO AVERAGE DAILY FLOW UTILIZED TO DETERMINE TRUNK SEWER SIZES

| Population Range | Ratio of Peak Flow to Average Daily Flow[a] |
|---|---|
| 0 - 2,000 . . . . . . . . . . | 5.0 |
| 2,000 - 10,000 . . . . . . | 4.0 |
| 10,000 - 20,000 . . . . . | 3.0 |
| More than 20,000 . . . . | 2.5 |

[a] *This ratio applies to sanitary sewage flow but not to infiltration and storm water inflow.*

*Source: Adapted by Harza Engineering Company from ASCE Manual No. 37, Design and Construction of Sanitary and Storm Sewers, 1969, p. 33.*

inflow on a regional basis was estimated to be 125 gpcd, or about 9.88 gpm per acre. The combined per capita contribution noted above for infiltration and inflow of 209 gpcd is in the same order of magnitude but slightly higher than the value of 170 gpcd utilized in the development of the regional sanitary sewerage system plan, based upon an analysis of sample sewer systems serving typical low-, medium-, and high-density neighborhoods with a conservative allowance for infiltration and inflow of all the components of the sewer system. The findings of the areawide water quality management planning program would be expected to be somewhat higher than the theoretical values estimated since they reflect conditions in certain areas with significant sewer system rehabilitation needs. It is expected that the quantity of infiltration and inflow will be reduced in the future due to the conduct of sewer system rehabilitation programs. For sewer design purposes, it is concluded that an allowance of 170 gpcd is a conservative estimate to be utilized in sewer sizing for the peak flow contribution from infiltration and inflow. Utilizing this value, the criteria for trunk sewer design utilized in the regional sanitary sewerage system plan and noted in Table 18 are applicable for systems level analysis under the areawide water quality management planning program.

SEWRPC Planning Report No. 16 included a detailed discussion illustrating that this procedure to size trunk sewers is sufficiently precise for the stated purpose of evaluating alternative trunk sewer configurations and selecting the most economic system; that is, the procedure will adequately determine the relative costs between alternative sewerage system configurations.

The design criteria summarized in Table 18 were utilized in the areawide water quality management planning program to size all sewerage system components except sewage treatment plants. The criteria were not, however, used to size trunk sewers lying within the service area of the Milwaukee-Metropolitan Sewerage Commissions, where the long-range system plan adopted by those Commissions were incorporated into the regional system plan without change. Refinements, including possible staging beyond the plan design year, are expected to be developed under the present facilities planning program being conducted by the Milwaukee Metropolitan Sewerage District. Modifications developed under that planning program are being coordinated with the regional planning programs and, upon completion, will be incorporated into the areawide water quality management planning program.

Wastewater treatment plants are frequently sized to treat wastewater at an average daily flow rate, including a constant groundwater infiltration volume. Plants can be sized at relatively small additional costs to provide a hydraulic capacity of several times the average design flow rate without bypassing, but with a loss in treatment efficiency. Generally, the flow at wastewater treatment plants is more than the average daily flow from about 8 a.m. until about 8 p.m., and is less than the average daily flow for the remainder of the day. The concentrations of suspended solids and five-day biochemical oxygen demand ($BOD_5$) are also greater than the average concentrations during the period when the flow is higher.

In the areawide water quality management planning program, the design capacity of wastewater treatment plants was obtained by adding to the 1975 average wastewater flow the estimated incremental wastewater flow resulting from the planned resident population change between the year 1975 and the design year 2000, based on a flow rate of 210 gpcd. A constant rate of infiltration was assumed at 85 gpcd which, when added to the assumed wastewater flow rate of 125 gpcd, provided the design flow of 210 gpcd.

The average design wastewater flow components of 125 gpcd for domestic flow and 85 gpcd for infiltration were utilized in the sanitary sewerage system plan as documented in SEWRPC Planning Report No. 16, and correspond closely to the average values of 121 and 84 gpcd for average sewage flow and infiltration contributions indicated by the analyses of existing wastewater treatment plant loadings conducted under the areawide water quality management planning effort. Since wastewater effluent standards as well as treatment plant design generally address the requirement for monthly average limitations, design criteria have been established such that the maximum monthly average wastewater flow can be adequately treated. Thus, the design flow loading rate of 210 gpcd was reviewed to determine its suitability for a design basis, for achievement of monthly average limits when also considering the effect of possible flow reduction practices which could be expected in the future.

In addition to wastewater contributions from domestic, commercial, and industrial sources, infiltration contributions to treatment plant wastewater flow have been considered in establishing an annual average or maximum monthly design loading. The contribution of wastewater from inflow is an important consideration in establishing design flows over relatively short periods of time such as daily or hourly peak flow periods, but is not generally a major consideration in establishing annual or monthly average design flow conditions. As previously noted, the average per capita infiltration contribution of wastewater in the Region is 84 gpcd. Detailed groundwater infiltration and clear water inflow analyses of sewer systems conducted under various local facilities planning efforts in the Region report varying degrees of sewer system rehabilitation as cost effective in reducing infiltration and inflow. Table 21 summarizes the portion of the infiltration/inflow determined to be excessive in several of the infiltration/inflow analyses conducted for sewerage systems in the Region. This excessive infiltration/inflow is generally considered to be the portion which can be cost effectively removed when comparing the cost of the correcting infiltration/inflow conditions with the cost of wastewater treatment and conveyance.

Reported percentages of existing infiltration and inflow which can be cost effectively removed vary from none to more than 75 percent. However, removals of 50 to 70 percent are generally found to be the maximum practical except in cases where the infiltration and inflow are unusually high portions of the total system flow. The reduction in inflow generally accounts for a greater percentage of the total reduction in infiltration and inflow. It was assumed that infiltration contribution would be reduced by 20 percent. This reduction, when applied to the 84 gpcd regional infiltration contribution, results in a per capita infiltration contribution of about 67 gpd. The use of a 125 gpcd design wastewater flow from domestic, industrial, and commercial sources assumes water use and associated wastewater loading will not continue to increase in accordance with historic trends. It is expected that the increasing awareness of the need to conserve natural resources, along with the establishment of policies regarding the use of flow reduction techniques and the institution of wastewater treatment and conveyance charges based upon usage, will stop this trend which resulted in an increase in domestic water use from 67 gpcd to 88 gpcd from 1960 to 1970.

As documented in SEWRPC Technical Report No. 21, the ratio of maximum monthly average flow to annual average wastewater flow tributary to the wastewater treatment plants in the Region is 1.37. This variability of wastewater flow is due in part to infiltration contributions which are affected by seasonal variations in groundwater elevations. The reduction in infiltration and inflow previously discussed should also be reflected in a reduction in the ratio of maximum monthly average flow to annual average wastewater flow. Therefore, it was assumed that a reduction in the regional ratio of maximum monthly average flow to annual average wastewater flow from 1.37 to 1.20 could be effected. This ratio of 1.20, when applied to a per capita wastewater flow of 125 gpd and a per capita infiltration contribution of 67 gpd, results in a design flow loading rate of 217 gpcd. For systems planning purposes, this value is sufficiently close to the 210 gpcd utilized in the regional sanitary sewerage system plan to warrant continued use of that value in the areawide water quality management planning program.

Table 21

REPORTED EXCESSIVE INFILTRATION AND INFLOW IN SELECTED SANITARY SEWER SYSTEMS OF THE REGION

| Community | Percent Reduction Determined to be Cost Effective | | |
|---|---|---|---|
| | Infiltration | Inflow | Infiltration and Inflow |
| City of Cedarburg | 70 | 70 | 70 |
| City of Kenosha | 50[a] | 70[a] | -- |
| City of Milwaukee[b] | -- | -- | 12 |
| City of Port Washington | -- | -- | 70 |
| City of Racine | -- | -- | 57-65 |
| City of West Bend | -- | -- | 0 |
| City of Whitewater | 70 | 80 | -- |
| Village of Butler | 50 | 80 | 72 |
| Village of Dousman | -- | -- | 0 |
| Village of Grafton | -- | -- | 0 |
| Village of Jackson | -- | -- | 78 |
| Village of Mukwonago | -- | -- | 50 |
| Village of Oconomowoc | -- | -- | 50 |
| Village of Slinger | -- | -- | 5-25 |
| Village of Union Grove | -- | -- | 75 |
| Caddy Vista Sanitary District | -- | -- | 60 |
| Milwaukee Metropolitan Sewerage Commissions[c] | -- | -- | 0 |
| Milwaukee Metropolitan Sewerage Commissions[d] | -- | -- | 64 |
| Western Racine County Sanitary District | -- | -- | 50 |

[a] *Reported percentage of removal of the least cost alternative based on studies to determine if infiltration/inflow was excessive. Percentages of removal which will be most cost effective will be refined in a sewer system evaluation survey.*

[b] *Data obtained from Infiltration/Inflow Analysis of the Separated Sanitary Sewer System, City of Milwaukee, Wisconsin, Volume One, by Donohue and Associates, Inc., 1976.*

[c] *Data obtained from Sanitary Sewer System Infiltration/Inflow Analysis from Interceptor Project No. 865 and Tributary Systems, Volume One, by Donohue and Associates, Inc., 1976. Study area encompasses the northeast area of the Metropolitan Sewerage District, principally the communities of Bayside, Brown Deer, Fox Point, River Hills, and Thiensville, and portions of Glendale, Milwaukee, and Mequon. Further studies, including of other portions of the sewer systems lying within the service area of the Milwaukee-Metropolitan Sewerage Commissions, are being conducted during 1978. Preliminary findings of that study indicate the existence of excessive infiltration and inflow and recommend that a sewer system evaluation survey be conducted in most of the service area.*

[d] *Data obtained from Metropolitan Sewerage District of the County of Milwaukee, Intercepting Sewer Project No. 813, Infiltration/Inflow Analysis, by Donohue and Associates Inc., 1975. Study area includes the Village of Germantown and the Village of Menomonee Falls.*

*Source: SEWRPC.*

Wastewater Characteristics: The strength of domestic sewage is most commonly measured in terms of suspended solids and $BOD_5$. In the regional sanitary sewerage system planning program, average daily per capita contributions of 0.21 pound of suspended solids and $BOD_5$ each were assumed. The nitrogen loading to a municipal wastewater treatment plant was assumed to be 0.054 pound per capita per day as total nitrogen, with 0.027 pound per day—approximately 50 percent of the total nitrogen in the influent—being ammonia. Nitrogen in the organic form was assumed to be 45 percent of the total nitrogen in the influent, or 0.024 pound per capita per day. The remaining 5 percent of the total nitrogen, 0.003 pound, was assumed to be in the nitrate form. Phosphorus waste loads were assumed in the regional sanitary sewerage system planning program to total 0.014 pound (as elemental phosphorus) per capita per day.

Table 22

COMPARISON OF 1975 REGIONAL WASTEWATER CHARACTERISTICS TO THE WASTEWATER CHARACTERISTICS UTILIZED IN THE REGIONAL SANITARY SEWERAGE SYSTEM PLAN

| Parameter | Regional Sanitary Sewerage System Plan Design Value (pounds per capita per day) | Average Wastewater Strength Based upon Inventory Conducted under the Areawide Water Quality Management Planning Program | |
|---|---|---|---|
| | | Average[a] Not Weighted by Population (pounds per capita per day) | Average[b] Weighted by Population (pounds per capita per day) |
| Five-Day Biochemical Oxygen Demand | 0.21 | 0.16 | 0.49 |
| Suspended Solids | 0.21 | 0.19 | 0.53 |
| Organic Nitrogen | 0.024 | 0.011 | 0.009 |
| Ammonia-Nitrogen | 0.027 | 0.016 | 0.016 |
| Total Phosphorus | 0.01 | 0.01 | 0.01 |

[a] *Average is calculated as the mean value of the individual treatment plant per capita values.*

[b] *Average is calculated as the total regional influent loading in pounds per day divided by the tributary population.*

*Source: SEWRPC.*

The per capita contributions of treatment plant influent parameters which were determined under the areawide water quality management planning program are compared to the regional design values utilized in the development of regional sanitary sewerage system plan in Table 22. The detailed data utilized in developing the regional average values are reported in Chapter III of SEWRPC Technical Report No. 21.

The regional $BOD_5$ and suspended solids per capita contributions are much greater when calculated on a population-weighted basis, reflecting the much higher per capita contributions in the larger and generally more industrialized communities. Because of the variability in the per capita contributions exhibited throughout the Region, particularly with respect to $BOD_5$, the analysis of alternatives conducted under the areawide water quality management planning program did not establish a single per capita contribution of wastewater influent characteristics in the development and analysis of alternative plans. Rather, the known characteristics of existing influents at individual treatment plants were utilized in applying alternative treatment practices and the cost and effectiveness of these practices to the public wastewater treatment systems. The development of the point source water pollution control practices, and the cost and effectiveness of those practices, was based upon a categorical grouping based upon the influent characteristics of the treatment plants in the Region. This procedure is documented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control for Southeastern Wisconsin, Volume One, Point Sources.

Identification and Test of Control Measures: The basic procedure used to develop the alternative water quality management plans described herein was to identify the factors affecting water quality in each reach of lake and stream system studied—factors which included stream and lake flow conditions, existing and forecast point source discharges to the surface water system, and existing and potential diffuse sources of pollution. These factors were evaluated to identify possible effective approaches to required water pollution abatement. By an iterative process, the level of reduction required in point and nonpoint sources of pollution to meet applicable water quality standards as represented by water quality-duration relationships forms the basis for the location and design of alternative point and diffuse source control measures. Table 23 presents a a generalized summary of the methods and assumed range of effectiveness of practices for the control of point sources of pollution from wastewater treatment plants used in the plan development. This information, as well as cost data fundamental to the development of plan alternatives set forth in this chapter, is presented in more detail in Volume One of SEWRPC Technical Report No. 18.

Table 23

## GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF POINT SOURCE WATER POLLUTION CONTROL MEASURES

| Treatment Level[a] | Basic Effluent Criteria | Unit Processes[b] | Expected Effluent Quality (mg/l)[c] |
|---|---|---|---|
| 1 | Five-Day Biochemical Oxygen Demand: 30 mg/l | PS+AS+FC or PS+TF+FC+M or F[d] or PS+BD+FC or CS+FC+M or F[d] | Five-Day Biochemical Oxygen Demand: 20-30<br>Suspended Solids: 15-35<br>Total Phosphorus: 9-16<br>Ammonia-Nitrogen: 9-15 |
| 2 | Five-Day Biochemical Oxygen Demand: 30 mg/l<br>Total Phosphorus: 1 mg/l[e] | C+PS+AS+C+FC or C+PS+TF+C+FC+M or F[d] or C+PS+BD+C+FC | Five-Day Biochemical Oxygen Demand: 15-30<br>Suspended Solids: 15-25<br>Total Phosphorus: 1[e]<br>Ammonia-Nitrogen: 9-15 |
| 3 | Five-Day Biochemical Oxygen Demand: 20 mg/l | PS+AS+FC+M or F[d] or PS+TF+FC+M or F[d] or CS+FC+M or F[d] | Five-Day Biochemical Oxygen Demand: 15-20<br>Suspended Solids: 12-25<br>Total Phosphorus: 8-15<br>Ammonia-Nitrogen: 9-15 |
| 4 | Five-Day Biochemical Oxygen Demand: 15 mg/l | PS+AS+FC+M or F[d] or CS+FC+M or F | Five-Day Biochemical Oxygen Demand: 15<br>Suspended Solids: 10-20<br>Total Phosphorus: 9-15<br>Ammonia-Nitrogen: 9-15 |
| 5 | Five-Day Biochemical Oxygen Demand: 15 mg/l<br>Total Phosphorus: 1 mg/l[e] | C+PS+AS+C+FC+F[d] or C+PS+TF+C+FC+F | Five-Day Biochemical Oxygen Demand: 12-15<br>Suspended Solids: 5-15<br>Total Phosphorus: 1[e]<br>Ammonia-Nitrogen: 9-15 |
| 6 | Five-Day Biochemical Oxygen Demand: 15 mg/l<br>Total Phosphorus: 1 mg/l[e]<br>Ammonia-Nitrogen: 1.5 mg/l | C+PS+AS+C+IC+N+FC or C+PS+TF+C+IC+N+FC or PS+AS[f]+FC+LA | Five-Day Biochemical Oxygen Demand: 10-15[g]<br>Suspended Solids: 12-20[g]<br>Total Phosphorus: 1[g,e]<br>Ammonia-Nitrogen: 1.5[g] |
| 7 | Five-Day Biochemical Oxygen Demand: 15 mg/l<br>Ammonia-Nitrogen: 1.5 mg/l | EA+FC+M or F[d] or PS+AS[f]+FC+LA or AL+PL+LA | Five-Day Biochemical Oxygen Demand: 10-15[g]<br>Suspended Solids: 12-20[g]<br>Total Phosphorus: 9-15[g]<br>Ammonia-Nitrogen: 1.5[g] |
| 8 | Five-Day Biochemical Oxygen Demand: 10 mg/l<br>Total Phosphorus: 1 mg/l[e]<br>Ammonia-Nitrogen: 1.5 mg/l<br>Dissolved Oxygen: 6 mg/l (minimum) | C+PS+AS+C+IC+N+FC+M+P or C+PS+TF+C+IC+N+FC+M+P or PS+AS[f]+FC+LA | Five-Day Biochemical Oxygen Demand: 8-10[g]<br>Suspended Solids: 5-12[g]<br>Total Phosphorus: 1.0[e,g]<br>Ammonia-Nitrogen: 1.5[g]<br>Dissolved Oxygen: 6.0 (minimum) |
| 9 | Five-Day Biochemical Oxygen Demand: 5 mg/l<br>Total Phosphorus: 1 mg/l[e]<br>Ammonia-Nitrogen: 1.5 mg/l<br>Dissolved Oxygen: 6 mg/l (minimum) | C+PS+AS+C+IC+N+FC+F+AC+P or C+PS+TF+C+IC+N+FC+F+AC+P or PS+AS[f]+FC+LA | Five-Day Biochemical Oxygen Demand: 3-5[g]<br>Total Phosphorus: 1.0[g]<br>Ammonia-Nitrogen: 1.5[g]<br>Dissolved Oxygen: 6.0[g] (minimum) |

LEGEND

AC - Activated Carbon
AL - Aerated Lagoon
AS - Activated Sludge
BD - Rotating Biological Contactor
C - Chemical Treatment
CS - Contact Stabilization
EA - Extended Aeration
F - Filter
FC - Final Clarifier
IC - Intermediate Clarifier
LA - Land Application
M - Microstrainer
N - Nitrification
P - Post Aeration
PL - Polishing Lagoon
PS - Primary Sedimentation
TF - Trickling Filter

[a] *As defined in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control for Southeastern Wisconsin, Volume One, Point Sources.*

[b] *All treatment levels include pretreatment and chlorination unit processes.*

[c] *Quality variations due to varying influent conditions and type of treatment units utilized.*

[d] *Tertiary treatment unit not required with influent having low wastewater characteristic strength.*

[e] *In addition to the levels noted, another treatment step was utilized in the development and evaluation of point source control alternatives that step providing a high level of advanced waste treatment producing an effluent total phosphorus concentration of about 0.1 mg/l. This higher level of treatment assumes use of an effluent land application system or of two-stage chemical clarification and filtration prior to discharge to the surface waters.*

[f] *Other biological secondary systems can be substituted for activated sludge.*

[g] *Removals for land application schematics depend on soil type and cropping practice.*

*Source: SEWRPC.*

For the assumed design year 2000 conditions, point source alternative analyses considered controls needed to attain effluent concentrations of $BOD_5$, suspended solids, ammonia-nitrogen, phosphorus, and fecal coliform generally determined to be needed to achieve the adopted water use objectives and water quality standards for each stream of the Region. In addition, treatment or wastewater controls associated with the Wisconsin Pollution Discharge Elimination System (WPDES) permit process and the federal- and state-defined requirements for "best available technology"[6] were considered. Finally, connecting industrial discharges to the public sanitary sewer system was considered, as was providing the degree of wastewater control needed to provide a continued surface water discharge. Conversely, eliminating industrial connections discharging unpolluted wastewaters to the public sewer systems and discharging that waste to the surface waters was considered.

In order to recommend point and diffuse source control measures, the sources of pollution that were resulting in the violation of water quality standards needed to be determined. In general, it was found that diffuse source controls were not substitutable for point source controls. Point sources were usually found to be the primary cause of phosphate phosphorus and un-ionized ammonia-nitrogen violations, while fecal coliform violations were usually generated by the effects of diffuse sources. Dissolved oxygen problems within the Region were usually caused by high oxygen demand from bottom deposits and benthic organisms. (Bottom deposits are attributable to excessive historical and existing point source discharges, flow relief devices, and diffuse source loadings.) These dissolved oxygen problems in most cases are expected to be abated by the implementation of the recommended point source controls and minimum diffuse source controls. Additional point source controls beyond those proposed in SEWRPC Planning Report No. 16 were relatively ineffective in ameliorating fecal coliform problems under year 2000 land use conditions, and diffuse source controls were not generally effective in controlling instream phosphate-phosphorus or un-ionized ammonia-nitrogen levels, especially in rural areas. Hence, a true alternative selection of additional point source controls versus diffuse source controls seldom existed. In cases where alternative selections between point and diffuse source controls did exist, the least costly pollution abatement measure was always apparent and that control measure was thus recommended.

[6]*Required effluent limitations for industrial point sources which must be achieved no later than July 1, 1983 using the best available technology economically achievable, as defined for a category or class of point source by the actions of the Administrator of the U. S. Environmental Protection Agency. (See Section 301(32)B(2)A of Public Law 92-500.)*

Diffuse Source Control Design Procedures

A major finding of the areawide water quality management planning program is that a moderate level of nonpoint or diffuse source pollution abatement will be needed to meet the recommended water use objectives and supporting standards. The development of the nonpoint source element of the water quality plan was based upon the determination of a required level of reduction of diffuse source pollutants.

Existing and Planned Land Use Conditions: Year 1970 land use conditions, 1985 stage planned land use conditions, and design year 2000 planned land use conditions and attendant resident population and employment levels were developed by the Commission as part of the land use planning program and were used to identify existing areas suited to specific practices, along with the probable change in the extent of these areas over the design period. These forecasts allowed cost estimates to be developed to the design year. Livestock populations identified in a 1975 Commission inventory were used to develop cost estimates of animal waste control systems. Although total livestock populations have been declining within the Region, no further declines in such populations are assumed to occur through the year 2000. The estimated livestock management costs, however, are based upon the number of animals in livestock herds in excess of 25 equivalent animal units. (An animal unit is equal to the waste production of a 1,000-pound cow.) Any future decline in total livestock populations should generally occur through the loss of smaller herds and, therefore, should not significantly affect the cost estimates.

Identification and Test of Control Measures: The basic procedure used to develop the alternative water quality management plans described herein was to identify the factors affecting water quality in each reach of the stream and lake systems studied—factors which included lake and stream bottom and flow conditions as well as existing and potential sources of pollution. These factors were analyzed and evaluated to identify possible effective approaches to required water pollution abatement.

The level of reduction in pollutant accumulations on the land surface required to meet applicable water quality standards, as represented by the water quality-frequency-duration relationships, forms the basis for the location and design of alternative diffuse source control measures. Table 24 sets forth the diffuse source control measures applicable to general land uses and diffuse source activities, along with the estimated maximum level of pollution reduction which may be expected upon implementation of the applicable measures. The table also includes information pertaining to the costs of developing the alternatives set forth in this chapter, which are presented in more detail in SEWRPC Technical Report No. 18, Volume Three, Urban Storm Water Runoff, and Volume Four, Rural Storm Water Runoff. The recommended level of reduction was based on the water quality simulation analyses discussed below for each watershed.

Table 24

## GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF DIFFUSE SOURCE WATER POLLUTION CONTROL MEASURES

| Applicable Land Use | Control Measures[a] | Summary Description[b] | Approximate Percent Reduction of Released Pollutants[c] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Urban | Litter and pet waste control ordinance | Prevent the accumulation of litter and pet wastes on streets and residential, commercial, industrial, and recreational areas | 2-5 | Ordinance administration and enforcement costs are expected to be funded by violation penalties and related revenues |
| | Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning | Improve the scheduling of these public works activities, modify work habits of personnel, and select equipment to maximize the effectiveness of these existing pollution control measures | 2-5 | No significant increase in current expenditures is expected |
| | Management of onsite sewage treatment systems | Regulate septic system installation, monitoring, location, and performance; replace failing systems with new septic systems or alternative treatment facilities; develop alternatives to septic systems; eliminate direct connections to drain tiles or ditches; dispose of septage at sewage treatment facility | 10-30 | Replace one-half of estimated existing failing septic systems with properly located and installed systems and replace one-half with alternative systems, such as mound systems or holding tanks; all existing and proposed onsite sewage treatment systems are assumed to be properly maintained; assume system life of 25 years. The estimated cost of a septic tank system is $2,300 and the cost of an alternative system is $4,500. The annual maintenance cost of a disposal system is $45. A holding tank would cost $1,300 with an annual operation and maintenance cost of $1,200. However, because septic system management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, these costs are not included as part of the areawide water quality maintenance plan |
| | Increased street sweeping | On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas | 30-50 | Estimate curb miles based on land use, estimated street acreage, and Commission transportation planning standards; assume one street sweeper can sweep 2,000 curb miles per year; assume sweeper life of 10 years; assume residential areas swept once weekly, commercial and industrial areas swept twice weekly. The cost of a vacuum street sweeper is approximately $38,000. The cost of the operation and maintenance of a sweeper is about $10 per curb/mile swept. |
| | Increased leaf and clippings collection and disposal | Increase the frequency and efficiency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings, and other organic debris to be mulched, composted, or bagged for pickup | 2-5 | Assume one equivalent mature tree per residence plus five trees per acre in recreational areas; 75 pounds of leaves per tree; 20 percent of leaves in urban areas not currently disposed of properly. The cost of the collection of leaves in a vacuum sweeper and disposal is estimated at $25 per ton of leaves |

Table 24 (continued)

| Applicable Land Use | Control Measures[a] | Summary Description[b] | Approximate Percent Reduction of Released Pollutants[c] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Urban (continued) | Increased catch basin cleaning | Increase frequency and efficiency of catch basin cleaning; clean at least twice per year using vacuum cleaners; catch basin installation in new urban development not recommended as a cost-effective practice for water quality improvement | 2-5 | Determine curb miles for street sweeping; vary percent of urban area served by catch basins by watershed from Commission inventory data; assume density of 10 catch basins per curb mile; clean each basin twice annually by vacuum cleaner. The cost of cleaning a catch basin is approximately $8 |
| | Reduced use of deicing salt | Reduce use of deicing salt on streets; salt only intersections and problem areas; prevent excessive use of sand and other abrasives | Negligible for pollutants addressed in this chapter but helpful for reducing chlorides and associated damage to vegetation | Increased costs, such as for slower transportation movement, are expected to be offset by benefits such as reduced automobile corrosion and damage to vegetation |
| | Improved street maintenance and refuse collection and disposal | Increase street maintenance and repairs; increase provision of trash receptacles in public areas; improve trash collection schedules; increase cleanup of parks and commercial centers | 2-5 | Increase current expenditures by approximately 15 percent. The annual cost per person is about $4 |
| | Parking lot storm water temporary storage and treatment measures | Construct gravel-filled trenches, sediment basins, or similar measures to store temporarily the runoff from parking lots, rooftops, and other large impervious areas; if treatment is necessary, use a physical-chemical treatment measure such as screens, dissolved air flotation, or a swirl concentrator | 5-10 | Design gravel-filled trenches for 24-hour, five year recurrence interval storm; apply to off-street parking acreages. For treatment—assume four-hour detention time. The capital cost of storm water detention and treatment facilities is estimated at $9,000 per acre of parking lot area, with an annual operation and maintenance cost of about $100 per acre. |
| | Onsite storage—residential | Remove connections to sewer systems; construct onsite storm water storage measures for subdivisions | 5-10 | Remove roof drains and other connections to sewer system wherever needed; use lawn aeration if applicable; apply dutch drain storage facilities to 15 percent of residences. The capital cost would approximate $200 per house, with an annual maintenance cost of about $10 |

Table 24 (continued)

| Applicable Land Use | Control Measures[a] | Summary Description[b] | Approximate Percent Reduction of Released Pollutants[c] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Urban (continued) | Storm water storage—urban | Store storm water runoff from urban land in surface storage basins or, where necessary, subsurface storage basins | 10-35 | Design all storage facilities for a 1.5 inch of runoff event, which corresponds approximately to a five-year recurrence interval event with a storm event being defined as a period of precipitation with a minimum antecedent and subsequent dry period of from 12 to 24 hours; apply subsurface storage tanks to intensively developed existing urban areas where suitable open land for surface storage is unavailable; design surface storage basins for proposed new urban land, existing urban land not storm sewered, and existing urban land where adequate open space is available at the storm sewer discharge site. The capital cost for storm water storage would range from $1,000-$10,000 per acre of tributary drainage area, with an annual operation and maintenance cost of about $20-$40 per acre |
| | Storm water treatment | Provide physical-chemical treatment which includes screens, microstrainers, dissolved air flotation, swirl concentrator, or high-rate filtration, and/or disinfection, which may include chlorination, high-rate disinfection, or ozonation to storm water following storage | 10-50 | To be applied only in combination with storm water storage facilities above; general cost estimates for microstrainer treatment and ozonation were used; same costs were applied to existing urban land and proposed new urban development. Storm water treatment has an estimated capital cost of from $900-$7,000 per acre of tributary drainage area, with an average annual operation and maintenance cost of about $35 per acre |
| Rural | Conservation practices | Includes such practices as strip cropping, contour plowing, crop rotation, pasture management, critical area protection, grading and terracing, grassed waterways, diversions, wood lot management, fertilization and pesticide management, and chisel tillage | Up to 50 | Costs for Soil Conservation Service (SCS)-recommended practices are applied to agricultural and related rural land; the distribution and extent of the various practices were determined from an examination of 56 existing farm plan designs within the Region. The capital cost of conservation practices ranges from $0.30-$14 per acres of rural land, with an average annual operation and maintenance cost of from $2-$4 per rural acre |

Table 24 (continued)

| Applicable Land Use | Control Measures[a] | Summary Description[b] | Approximate Percent Reduction of Released Pollutants[c] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Rural (continued) | Animal waste control system | Construct stream bank fencing and crossovers to prevent access of all livestock to waterways; construct a runoff control system or a manure storage facility, as needed, for major livestock operations; prevent improper applications of manure on frozen ground, near surface drainage-ways, and on steep slopes; incorporate manure into soil | 50-75 | Cost estimated per animal unit; animal waste storage (liquid and slurry tank for costing purposes) facilities are recommended for all major animal operations within 500 feet of surface water and located in areas identified as having relatively high potential for severe pollution problems. Runoff control systems recommended for all other major animal operations. It is recognized that dry manure stacking facilities are significantly less expensive than liquid and slurry storage tanks and may be adequate waste storage systems in many instances. The estimated capital cost and average operation and maintenance cost of a runoff control system is $90 per animal unit and $10 per animal unit, respectively. The capital cost of a liquid and slurry storage facility is about $425 per animal unit, with an annual operation and maintenance cost of about $30 per unit. An animal unit is the weight equivalent of a 1,000-pound cow |
| | Base-of-slope detention storage | Store runoff from agricultural land to allow solids to settle out and reduce peak runoff rates. Berms could be constructed parallel to streams | 50-75 | Construct a low earthen berm at the base of agricultural fields, along the edge of a floodplain, wetland, or other sensitive area, design for 24-hour, 10-year recurrence interval storm; berm height about four feet. Apply where needed in addition to basic conservation practices; repair berm every 10 years and remove sediment and spread on land. The estimated capital cost of base-of-slope detention storage would be about $250 per tributary acre, with an annual operation and maintenance cost of $10 per acre |
| | Bench terraces | Construct bench terraces, thereby reducing the need for many other conservation practices on sloping agricultural land | 75-90 | Apply to all appropriate agricultural lands for a maximum level of pollution control. Utilization of this practice would exclude installation of many basic conservation practices and base-of-slope detention storage. The capital cost of bench terraces is estimated at $625 per acre, with an annual operation and maintenance cost of $45 per acre |

Table 24 (continued)

| Applicable Land Use | Control Measures[a] | Summary Description[b] | Approximate Percent Reduction of Released Pollutants[c] | Assumptions for Costing Purposes |
|---|---|---|---|---|
| Urban and Rural | Public education programs | Conduct regional- and county-level public education programs to inform the public and provide technical information on the need for proper land management practices on private land, the recommendations for management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contact and education efforts | Indeterminate | For first 10 years includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied to for every 50,000 population. The cost of one person, materials, and support is estimated at $33,000 per year |
| | Construction erosion control practices | Construct temporary sediment basins; install straw bale dikes; use fiber mats, mulching and seeding; install slope drains to stabilize steep slopes; construct temporary diversion swales or berms upslope from the project | 20-40 | Assume acreage under construction is the average annual incremental increase in urban acreage; apply costs for a typical erosion control program for a construction site. The estimated capital cost and operation and maintenance cost for construction erosion control is $2,200 and $400 per acre under construction, respectively |
| | Materials storage and runoff control facilities | Enclose industrial storage sites with diversions; divert runoff to acceptable outlet or storage facility; enclose salt piles and other large storage sites in crib and dome structures | 5-10 | Assume 40 percent of industrial areas are used for storage and to be enclosed by diversions; assume existing salt storage piles enclosed by cribs and dome structures. The estimated capital cost of industrial runoff control is $1,100 per acre of industrial land. Material storage control costs are estimated at $30 per ton of material |
| | Stream protection measures | Provide vegetative buffer zones along streams to filter direct pollutant runoff to the stream; construct stream bank protection measures, such as rock riprap, brush mats, tree revetment, jacks, and jetted willow poles where needed | 5-10 | Apply a 50-foot-wide vegetative buffer zone on each side of 15 percent of the stream length; apply stream bank protection measures to 5 percent of the stream length. Vegetative buffer zones are estimated to cost $21,200 per mile of stream, and streambank protection measures cost about $37,000 per stream mile |
| | Pesticide and fertilizer application restrictions | Match application rate to need; eliminate excessive applications and applications near or into surface water drainageways | 0-3 | Cost included in public education program |
| | Critical area protection | Emphasize control of areas bordering lakes and streams; correct obvious erosion and other pollution source problems | Indeterminate | Indeterminate |

[a] *Not all control measures are evaluated for each watershed. The characteristics of the watershed, the estimated required level of pollution reduction needed to meet the applicable water quality standards, and other factors will influence the estimation of costs of specific practices for any one watershed. Although the control measures costed represent the recommended practices developed at the regional level on the basis of the best available information, the local implementation process should provide more detailed data and identify more efficient and effective sets of practices to apply to local conditions.*

[b] *For a more detailed description of pollution control measures for diffuse sources, see SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control for Southeastern Wisconsin, Volume Three, Urban Storm Water Runoff, and Volume Four, Rural Storm Water Runoff.*

[c] *The approximate effectiveness refers to the estimated amount of pollution produced by the contributing category (urban or rural) that could be expected to be reduced by the implementation of the practice. The effectiveness rates would vary greatly depending on the characteristics of the watershed and individual diffuse sources. It should be further noted that practices can have only a "sequential" effect, since the percent pollution reduction of a second practice can only be applied against the residual pollutant load which is not controlled by the first practice. For example, two practices of 50 percent effectiveness would achieve a theoretical total effectiveness of only 75 percent control of the initial load. Further, the general levels of effectiveness reported in the table are not necessarily the same for all pollutants associated with each source. Some pollutants are transported by dissolving in water and others by attaching to solids in the water; the methods summarized here reflect typical pollutant removal levels.*

*Source: SEWRPC.*

The practices to be considered for each watershed depend, among other things, on the estimated level of diffuse source pollution loading reduction found necessary to satisfy the applicable water use objectives and standards to the year 2000, and on the physical characteristics of the watershed. The sets of practices recommended for various levels of diffuse source pollution control are presented in Table 25. However, not all practices are needed, applicable, or cost-effective for all watersheds, due to variations in pollutant loadings and land use and natural conditions among the watersheds. Thus, these practices are proposed for general systems analysis purposes only; specific practices applicable and recommended for any given locality must be developed along local planning and design efforts. Such efforts could account for such local conditions as current land management practices and equipment availability. This level of planning is proposed as a local element of the continuing water quality management planning program for the Region, to be conducted by local community leaders, planners, resource managers, and engineers, with the assistance of county, regional, and state agencies. A locally prepared plan for nonpoint abatement measures should be better able to blend knowledge of current problems and practices with a quickly evolving technology to achieve a suitable, site specific approach to pollution abatement. It should be noted that wherever possible, the recommended practices are cost-effective with regard to water quality management for a specific watershed or lake drainage basin.

Table 25

ALTERNATIVE GROUPS OF DIFFUSE SOURCE WATER POLLUTION CONTROL MEASURES PROPOSED FOR STREAMS AND LAKE WATER QUALITY MANAGEMENT

| Pollution Control Category | Level of Pollution[b] Control | Practices to Control Diffuse Source Pollution from Urban Areas[c] | Practices to Control Diffuse Source Pollution from Rural Areas[c] |
|---|---|---|---|
| Minimum or Low-Cost Diffuse Source Control Practices[a] | Variable | Public education programs, litter and pet waste control, restricted use of fertilizers and pesticides, construction erosion control, septic tank system management, critical area protection, improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning, material storage facilities and runoff control | Public education program, fertilizer and pesticide management, critical area protection, crop residue management, chisel tillage, pasture management, contour plowing, livestock waste control, construction erosion control |
| Additional Diffuse Source Control Practices[a] | 50 percent | Above, plus: Increased street sweeping, improved street maintenance and refuse collection and disposal, increased catch basin cleaning, stream protection, increased leaf and vegetation debris collection and disposal | Above, plus: Crop rotation, contour strip-cropping, grass waterways, diversions, wind erosion controls, terraces, stream protection |
| | 75 percent | Above, plus: An additional increase in street sweeping, use of onsite storm water storage measures in residential areas, parking lot storm water runoff storage and treatment, use of urban storm water storage facilities | Above, plus: Base-of-slope detention storage |
| | More than 75 percent | Above, plus: Urban storm water treatment with physical-chemical and/or disinfection treatment measures | Bench terraces[d] |

[a] *In addition to diffuse source control measures, lake rehabilitation techniques may be required to satisfy lake water quality standards.*

[b] *The required level of diffuse source reduction is identified for each watershed from the water quality analyses and for each lake tributary area from annual phosphorus load analyses. The percent reduction refers to the portion of pollutant runoff from urban or rural land—excluding pollutants controlled by minimum practices—which can be controlled by the implementation of those practices.*

[c] *Groups of practices are presented here for general analysis purposes only. Not all practices are applicable to, or recommended for, all lake and stream tributary watersheds. For costing purposes, construction erosion control practices, public education programs, and material storage facilities and runoff control are considered urban control measures and stream protection is considered a rural control measure.*

[d] *The provision of bench terraces would exclude most basic conservation practices and base-of-slope detention storage facilities.*

*Source: SEWRPC.*

It must be noted that urban areas have characteristics that differ from rural areas and complicate preparation of a diffuse source pollution abatement plan. Because man, along with his structures and activities, dominates the urban portion of the watershed, there are many more ways in which diffuse source pollution is generated in an urban area and, therefore, many different measures available to mitigate that pollution. Some urban diffuse source pollution control measures can be accomplished at only minimal cost, with the basic requirement being cooperative efforts by an enlightened public and implementing authorities. These low-cost measures include: litter and pet waste control ordinances; proper application of chemical and organic fertilizers and pesticides to lawns, golf courses, and park land; control of debris through provisions of ample trash receptacle areas and voluntary actions; improved general housekeeping practices; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection. In addition, public education programs are needed to provide technical information, as well as to inform the public of the progress of the planning and implementation programs, the effects of implemented measures, and the revisions in the initial plan. These low-cost measures have been combined with others considered to be needed for sound land management and minimum water quality protection, including construction erosion control and proper management of onsite wastewater treatment systems, into a category of urban practices which are generally recommended throughout the Region regardless of the degree of urban diffuse pollutant control needed to meet water use objectives. It is expected that the implementation of these practices will be beneficial in controlling adverse water quality conditions not specifically simulated under the areawide water quality management planning program, such as pollution from sediment or toxic and hazardous substances or limited localized pollution problems. For rural areas, minimum land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, contour plowing, livestock waste control, and construction erosion control, as well as public education programs, should be implemented to protect the water quality and are generally recommended throughout the Region.

The analyses presented in SEWRPC Technical Report No. 21, which identified the relative magnitude of all significant pollution sources, were used to determine the need for additional diffuse source control beyond the level achieved by the implementation of minimum practices. The minimum practices—particularly construction erosion control, management of onsite sewage disposal systems, and livestock waste control—frequently were estimated to achieve a high level of diffuse source pollution control. If further diffuse source controls were needed, the practices presented in Table 25 were considered. In this way, only the most cost-effective diffuse source controls needed to meet water use objectives are recommended. As noted earlier, point and diffuse source controls were generally not substitutable. Point sources were usually found to be the primary cause of phosphate phosphorus and un-ionized ammonia-nitrogen violations, while fecal coliform violations were usually generated by the effects of diffuse sources. Hence, a true alternative selection of additional point source controls versus diffuse source controls seldom existed. In cases where alternative selections between point and diffuse source controls existed, the least costly pollution abatement measure was generally apparent and that control measure was recommended.

Certain assumptions were necessary for development of systems level recommendations for urban storm water control. Urban storm water storage and treatment structural measures were considered as alternative pollution abatement measures only when a maximum level of urban diffuse source control was necessary. Design and cost criteria for these measures were developed from the Commission inventories of storm sewer drainage area outfall locations and tributary land use, SEWRPC Technical Report No. 18, Volume Three, Urban Storm Water Runoff, and SEWRPC Study Volume Memoranda pertaining to urban diffuse source control practices. All storage measures were designed to store 1.5 inches of runoff, which corresponds approximately to a five-year recurrence interval precipitation event—an event defined as a period of precipitation with a minimum antecedent and subsequent dry period of from 12 to 24 hours. This event was chosen for the areawide systems level planning and was based on the expected range of pollutant removal and costs of various runoff design capacities and on the need to utilize an event which would be consistent with the needed storage dewatering time. Refinements in the storage capacity should be considered at the local planning level to coordinate the storage facilities with the hydraulic design considerations utilized in design of local storm water drainage systems. A subsurface storage tank was considered only where the urban area served was already developed and storm sewered, and the logical storm water storage site was in intensive use, precluding surface storage basins. In general, proposed new urban development, or existing urban development, whose primary tributary area was lightly developed or open land was assumed to be amenable to application of the less expensive surface storage basins. The level of urban storm water treatment, if needed, was determined by identifying the percentage of an urban area to be served by physical/chemical treatment or by disinfection, as estimated from water quality analyses and treatment effectiveness estimates. While, in general, storm water storage and treatment measures were not found to be needed based on a systems level analysis, it is anticipated that these measures will be appropriate alternative pollution abatement measures to be considered in local planning activities.

Estimation and Evaluation of Costs of Control Measures

The economic aspects of point and diffuse source controls are important to the selection of alternative control measures and the recommendation of a water quality plan. With respect to water quality management planning, the cost effectiveness of a given practice refers to the cost of that practice and the potential pollution load reduction that may occur from the implementation of that practice. Therefore, the most cost-effective practice provides the largest potential pollution reduction for the smallest cost.

The monetary costs of structural alternatives can be evaluated using the cost curves presented in SEWRPC Technical Report No. 18, Volume One, Point Sources. The report includes major design criteria on each curve. The cost basis for all curves in August 1976 and the costs of individual diffuse source control practices are based on the costs presented in SEWRPC Technical Report No. 18, Volume Three, Urban Storm Water Runoff, and Volume Four, Rural Storm Water Runoff. To accelerate the capital costs to estimated January 1978 costs, a factor of 1.09 may be applied.

The costs obtained from the cost curves are sufficiently accurate for areawide systems planning and should be refined during project planning. At the areawide systems level of planning, the cost information is used to compare alternatives on a consistent basis.

The costs and technical effectiveness of control practices were estimated and a cost analysis was conducted for each alternative plan and for the recommended year 2000 point source control level. The cost analysis provides an important basis for the evaluation of the economic aspects of the alternative plans considered. It must be recognized, however, that no management decision is based on economics alone, and other considerations will also influence decisionmaking.

The cost estimates for diffuse source controls presented for lake drainage basins are the expected costs to reduce pollutant loads to the direct tributary drainage area of each lake, and exclude costs to reduce pollutant loads to major streams which discharge into the lake. The costs required for the major inflow streams to satisfy stream water quality standards are included in the watershed stream costs. The level of diffuse source control required for a lake does not affect the recommended diffuse source controls needed for inflow streams unless the lake cannot realistically satisfy the nutrient standard without additional inflow nutrient reductions. If additional diffuse source controls are needed for inflow streams, the increased cost is presented for the lake.

Design Period and Economic Life: The physical life of a property is that period between the original acquisition and final disposal of the property. The physical life of a given property is usually longer than the economic life. The economic life is defined as the period after which the incremental benefits from continued use no longer exceed the incremental cost of operation. In the economic analyses conducted under the areawide water quality planning program, the time period over which a facility is totally depreciated is made equal to the economic life.

A 25-year design period was selected for the areawide water quality planning program. This design period is consistent with that utilized by the Commission in its other planning programs and, in particular, represents the design period utilized for the regional land use plan. It is recognized, however, that the economic life of sanitary sewers and certain other structural control facilities may exceed that of the plan design period. Accordingly, for purposes of the economic analyses, an economic life of 50 years was assumed for sewers, force mains, lagoons, storage structures, and land; an economic life of 25 years was assumed for pumping and lift stations and wastewater treatment facilities.

While the plan design period is 25 years, from 1975 to 2000, the economic analysis period runs from 1975 to 2025, based on the longest economic life of components of the areawide water quality management plan. Cost computations under the plan assume that construction of major system elements such as sewers, pumping and lift stations, and wastewater treatment plants and that the acquisition of land will begin between 1980 to 1985. All costs, however, are expressed in 1976 dollars.

Following the principles of engineering economic analyses, no escalation of costs for construction, operation, maintenance, or replacement was considered. In the economic evaluations, provisions for the replacement of shorter-lived components are incorporated in total economic costs through the selection of an economic life. The economic analyses of alternatives assumes replacement of facilities at specific life intervals. Although it can be rightly argued that concrete structures have longer lives than 25 years, it can be countered that sewers may have longer lives than 50 years. Therefore, the relative economic comparisons will result in the same conclusions. A salvage value was credited to facilities whose economic life extended beyond the year 2025. For example, a sewer with a life of 50 years assumed to be constructed in 1995 was given a credit for 20 years of life after 2025.

Interest Rate: An interest rate of 6 percent was used in all of the economic analyses under the regional areawide water quality management planning program. The 6 percent interest rate had previously been used by the Commission in economic evaluations under the Root, Fox, Milwaukee, and Menomonee River watershed studies and regional sanitary sewerage system plan. While interest rates from 4 to 10 percent are often proposed for studies of this nature, a value of 6 percent is considered reasonable because it represents the approximate rate to citizens on conservative investments and, therefore, is representative of the cost to the individual of foregoing opportunities for investment elsewhere. Current U. S. Environmental Protection Agency guidelines recommend using 6 3/8 percent interest rate instead of the 6 percent rate generally used by the Commission. The difference between these two rates is slight and of no real consequence. Evaluation of the economic analysis factors as a function of interest rate and length of analysis period showed that no significant change in the relative costs of alternative plans would result if the higher interest rate were used.

Depreciation and Salvage Values: For the purpose of the economic analyses conducted under the planning program, it was assumed that all of the facilities would depreciate at an average annual rate over the economic life. At the end of economic life it was assumed that no value remained; thus, no salvage values were included in the economic analyses except for those facilities with an economic life extending beyond the year 2025.

Construction Capital Costs: The construction costs of all facilities included in the plan were estimated from the series of curves presented in SEWRPC Technical Report No. 18 for point source control cost estimation. These construction costs were multiplied in the economic analyses by a factor of 1.35 to obtain capital costs. The additional 35 percent of the estimated construction costs is added to account for unforeseen items in the cost estimates (contingencies), engineering and legal fees, administrative costs, and financing costs. The multiplier was derived as shown in the following tabulation.

| | | |
|---|---|---|
| Construction Cost = | | 1.0 |
| Contingencies = | | 0.15 |
| Subtotal | | 1.15 |
| Engineering | = 1.15 x 0.08 | = 0.092 |
| Legal and Administrative | = 1.15 x 0.02 | = 0.023 |
| Interest during Construction | = 1.15 x 0.045 | = 0.052 |
| Subtotal | | 1.317 |
| Financing | = 1.317 x 0.03 | = 0.039 |
| Total (rounded) | | 1.35 |

The methods utilized to estimate costs of diffuse source control measures were based upon more generalized estimating techniques and do not specifically include a factor to cover the costs of contingencies, engineering and legal fees, administration costs, and financing costs. These added costs for diffuse source controls are highly variable and are dependent upon the type of practice. In most cases, the additional costs are made up chiefly of implementing management agency direct staff costs. These costs should be developed as part of local planning costs.

Present Worth and Annual Costs: Four terms are commonly used in preparing economic analyses of important engineering projects. These are the single payment present worth factor (PWF), the uniform series present worth factor (SPWF), the gradient present worth factor (GPWF), and the capital recovery factor (CRF).

The single payment present worth factor converts the cost of a single expenditure at some future time to a value at present or close to the present. The uniform series present worth factor converts a series of future uniform annual payments to equivalent present value. Where annual payments are increasing by a fixed amount per year, the gradient present worth factor is used to determine the present value of the series. This factor, multiplied by the gradient (annual increase), is added to the present worth of a series of payments, each equal the amount of the first year's payment to obtain total present worth. In a 10-year series, the gradient is equal to the difference between the tenth year cost and the first year cost divided by the time base minus one year. The divisor is always one less than the series length because the amount of the gradient is zero for the first period. This factor was applied to sewage treatment plant operation and maintenance costs, assuming that they increase in a straight line from the period of initial operating flow to the period of maximum flow at plant capacity. After the facility is operating at capacity, the present worth of operation and maintenance costs is calculated as the present worth of a uniform annual series starting at a point in the future equal to the gradient time base.

The present worth of future single, uniform, or non-uniform annual series payments is always less than the absolute value of the single payment or the sum of the annual payments. The capital recovery factor converts a lump payment at the beginning of a period into a series of uniform annual payments over the length of the period. The sum of these uniform annual payments is always greater than the lump payment.

The following is an example of the use of present worth and annual cost analyses:

> Assume that a sewage treatment plant designed with 10 million gallons per day (mgd) of capacity is to be constructed immediately at a cost of $5.5 million. The initial flow is 3 mgd and the plant will reach the design flow in 25 years. The annual operation and maintenance cost at 3 mgd is $0.11 million and the annual operation and maintenance cost at 10 mgd is $0.29 million. The present worth of this plant for a 50-year operation period is computed as follows (all values in millions of dollars):
>
> Present worth of initial construction = $5.5
>
> Present worth of replacement at 25 years = $\text{PWF}\frac{6\%}{25}(5.50) = 0.2330\ (\$5.50) = \$1.3$
>
> Present worth of operation and maintenance
>
> $$= \text{SPWF}\frac{6\%}{25}(\$0.11) + \text{GPWF}\frac{6\%}{25}\frac{(0.29-0.11)}{25-1}$$
>
> $$+ \text{SPWF}\frac{6\%}{25}(\$0.29)\ \text{PWF}\frac{6\%}{25}$$
>
> $$= (12.783)\ (\$0.11) + (115.973)\ (\$0.0075) + (12.783)\ (\$0.29)\ (0.2330) = \$3.1$$
>
> Total present worth = $5.5 + $1.3 + $3.1 = $9.9

The annual cost calculation is as follows:

> Annual cost of construction
>
> $$\text{CRF}\frac{6\%}{50} \times \$6.8 = 0.0634 \times \$6.8 = \$0.43$$
>
> Annual cost of operation and maintenance
>
> $$\text{CRF}\frac{6\%}{50} \times \$3.1 = 0.0634 \times \$3.1 = \$0.20$$
>
> Total annual cost = $0.63.

Estimation of Water Quality under Alternative Levels of Pollutant Control

In order to be most meaningful, the effectiveness of different means of water pollution control must be reported in terms of their probable effects on physical and chemical characteristics of the lakes and streams in the Region, and on the ability of the lakes and streams to support the intended water uses. Accordingly, baseline or existing water quality conditions were described in two ways. In Volume One, Chapter IV of this report a summary of historical and existing water quality conditions at 87 field sampling locations is presented. This information was then used to verify the results of simulating existing water quality conditions utilizing the hydrologic-hydraulic water quality simulation model. The simulation model was calibrated against field data collected during selected storm events and dry weather periods at 36 sampling stations from September 1, 1976 through April 1, 1977. The simulated existing conditions were then summarized in water quality concentration-frequency curves, which in turn were compared to the applicable water quality standards to prepare the water quality standards achievement charts presented in this chapter. The results were also analyzed considering the known water pollution sources within the watershed, as summarized in Volume One, Chapter V of this report. Simulation results were summarized for selected points on the hydrologic stream network, as well as for selected lakes, to provide for comparisons to data from the 87 field sampling locations, and to evaluate the water quality effects of the various physical features within the watershed. The respective areas between and tributary to the selected points used for analysis of simulation results are hereafter referred to as "water quality analysis areas," and constitute portions of the principal watersheds.

The water quality characteristics and problems of the watershed can be quantified not only for existing conditions but for the forecast conditions for the year 2000, based on the regional land use plan and on the regional sanitary sewerage system plan recommendations as they were amended herein. The results of the initial year 2000 simulation, which incorporated the initially estimated point source controls, were used to determine the need for alternative abatement levels for nonpoint source control as well as added point source control. Depending on the severity, extent, and spatial distribution of the remaining water quality problems identified, selected combinations of diffuse and point source controls were tested as reported in the watershed and subregional area discussions below.

The water quality standards associated with each of the water use objectives were presented in Chapter II of this volume. Results of the water quality simulation analyses indicated that achievement of the water quality standards on an absolute basis—that is, 100 percent of the time—was not feasible given the natural conditions in the Region and given the known techniques for water pollution control. A review of hourly simulated values for streams which exhibited a low level of violation (5-10 percent) indicated that neither the duration nor intensity of the violations were severe. Furthermore, an evaluation of relatively clean unpolluted streams in the Region indicated that even these streams do not satisfy the water quality standards 100 percent of the time. It must be recognized, therefore, that exceeding the standards for brief periods would not generally affect the intended use of the surface waters.

In the past, water quality has often been evaluated only during low flow periods in order to determine the effects of point sources. However, how often these standards are exceeded under periods of high flow, or during storm events following long intervening periods of dry weather and the associated pollutant buildup on the land surface—conditions which cause high pollutant washoff from the land surface—cannot be determined by applying the standards to all stream flows less than or equal to the 7 day-10 year flow conditions. Generally, such conditions have been found to have a significant effect on the achievement of water use objectives. Thus, the assessment of forecast water quality conditions against the physical and chemical criteria in the water quality standards was based upon the percent of time the water quality conditions were in compliance with the specified limits. Under this method, statistical analyses were prepared from the results of the continuous water quality simulation modeling to determine the percent of time a given standard is exceeded. These analyses included periods of high flow or moderate flow as well as periods of low flow. A 95 percent compliance level—meaning water quality standards shall be met 95 percent of the time—was selected as the criterion for those parameters which directly affect aquatic organisms—dissolved oxygen, temperature, un-ionized ammonia-nitrogen, and pH. A 90 percent compliance level was selected as the criterion for those parameters which do not directly affect aquatic organisms—phosphorus and fecal coliform. The analyses indicated that the achievement of an additional 5 percent compliance level for phosphorus and fecal coliform—which were found to be primarily related to recreational use potential—would frequently require an extremely high level of additional pollution control.

The water quality model utilized in the analyses simulates the phosphate form of phosphorus—the form which is most readily available for use by plants and consequently for the production of weeds and algae. The typical proportions of total phosphorus represented by phosphate-phosphorus are reported in the technical literature as ranging from approximately 25 percent in rural areas to 60 percent in urban areas.[7] In sewage treatment plant effluents in the Region, Commission analyses indicate that about 70 percent of the total phosphorus is in the phosphate form. Under low flow conditions, an even higher proportion—up to 100 percent—of the total phosphorus in streams may be expected to be in the form of phosphate-phosphorus. Commission stream sampling studies indicate that phosphate-phosphorus generally constitutes the majority—about 55 percent—

[7] *See International Joint Commission, Pilot Watershed Studies Summary Report, June 1978, and W. F. Cowen and G. Fred Lee, Phosphorus Availability in Particulate Materials Transported by Urban Runoff, Journal WPCF, 48:3580-591, March 1976.*

of the total phosphorus in the streams of the Region. Since phosphate comprises the majority of the total phosphorus, and since the hydrologic-hydraulic water quality simulation model in the planning program could not be used to simulate total phosphorus, the results of the model simulation of phosphate-phosphorus were utilized to test the conformance of alternative plans against the total phosphorus standard of 0.1 mg/l. This is analogous to applying a less stringent interpretation of the instream total phosphorus standard. The resulting instream total phosphorus concentration implied by a 0.1 mg/l phosphate-phosphorus value would be equal to about a 0.14 mg/l value of total phosphorus assuming a 70 percent proportion of phosphate-phosphorus. Assuming only 55 percent of the total phosphorus concentration to be phosphate, the implied total phosphorus would be only about 0.18 mg/l. Given the state-of-the-art of water quality simulation modeling and the current level of precision and quantification in biological research, this was deemed to be a sufficiently precise measure of the achievement of an instream phosphorus standard. It should be further noted that the simulation techniques used, like the physical measurements used as a basis for the simulation modeling, are not 100 percent accurate. Thus, it would not be wise to require too strict a compliance with simulated values and standards.

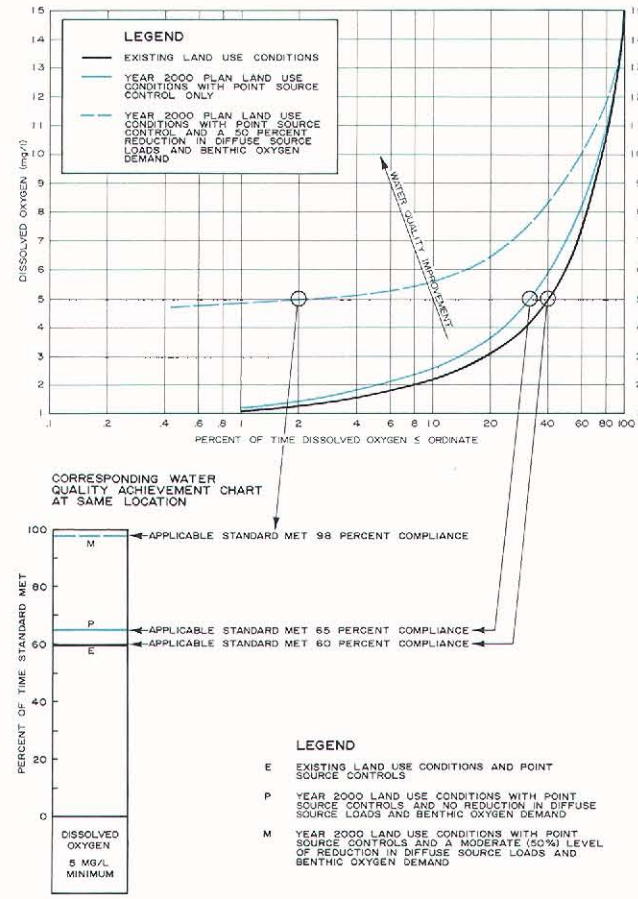
For each of the 232 simulation model water quality readout locations in or tributary to the Region, or downstream from the Region, the various simulation runs yielded a series of computed hourly values for at least eight water quality parameters. A voluminous amount of water quality data was thus computed in the simulation process. Since it was not practicable to display, examine, and analyze this voluminous data series, statistical analyses were performed to produce water quality-frequency curves for the parameters at each location and for each of the different conditions evaluated for each watershed.

A water quality-frequency curve is similar to the flow-frequency curve commonly used in hydrology, and is a graph indicating on the horizontal axis the percent of time during which an indicated level of a water quality measure—indicated on the vertical axis—is met or exceeded. Water quality-frequency relationships represent the overall impact of all the hydrologic-hydraulic-water quality processes that were simulated over the three-year period, weighing their impact against the frequency and magnitude with which they occur. The water quality-frequency curves were based on the universe of water quality values that were generated during simulation of the stream systems and permit an estimation of the percent of time that a desired water quality level may be expected to be maintained.

Water quality achievement charts for 125 of the simulation sites located on major streams in the Region were prepared from the water quality-frequency curves by reporting for each applicable water quality parameter the estimated probability of achieving the specified level. Figure 11 presents an example of a water quality-frequency curve for dissolved oxygen, along with the derived water quality achievement chart for an applicable

Figure 11

EXAMPLE OF WATER QUALITY FREQUENCY CURVE AND WATER QUALITY ACHIEVEMENT CHART FOR DISSOLVED OXYGEN




*Source: SEWRPC.*

standard of a minimum of 5.0 mg/l. For each different water quality condition—e.g., existing or future land use, point source abatement controls, nonpoint source abatement controls, or combinations thereof—the simulation results in a different water quality-frequency curve. The curve can be interpreted for the recommended water quality standard, resulting in a new amplitude of bars presented on the water quality achievement chart. It should be noted that a changed water quality standard, such as 3.0 mg/l of dissolved oxygen, would also prompt a reinterpretation of the water quality frequency curve. Utilizing the simulation results, the degree of pollutant control needed for the attainment of the 90 and 95 percent compliance levels for the parameters evaluated was then determined. In examining the water quality-frequency curves, judgment of the degree of achievement attained is required, as any absolute compliance level is not practical. In some cases, depending on the severity and extent of the violations or the slope of the frequency-duration curve, pollutant control levels which approached the selected water quality standard achievement level were judged as adequate. In other cases, when the levels of pollutant control needed could be estimated from completed simulations, a final simulation—to represent the recommended level of control—was not developed, in order to limit cost of the water quality modeling program.

The water quality-frequency curves and achievement charts could not be used directly to assess the violation of the ammonia-nitrogen standard because the toxic level varies with other parameters, such as temperature and pH, which change seasonally. The relation of simulated total ammonia-nitrogen levels to the applicable standard for un-ionized ammonia-nitrogen was assessed by utilizing the analysis of daily total ammonia-nitrogen simulation results at selected stations and the normally expected relation between total ammonia-nitrogen levels and un-ionized ammonia-nitrogen levels in the Region.

Stream Channel Rehabilitation

The ability of streams in southeastern Wisconsin to satisfy desired water use objectives is contingent on the tributary pollution loads to the stream and the instream characteristics. In recognizing the need to harmonize these two management aspects within a comprehensive water quality plan, the Commission proposes stream bank protection measures as a best management practice, in addition to land management measures. Stream bank protection measures—primarily designed to prevent erosion and preserve stream side vegetation—are most applicable to natural stream channels. However, portions of streams which flow through the highly urbanized areas of the Region—such as the Menomonee and Kinnickinnic River watersheds—have undergone major channel modifications. These channelized stream reaches require specialized management techniques to provide a suitable habitat for fish and other aquatic life which serve as important indicators of the chemical and biological condition of a stream.

Channel modifications—more commonly called channelization—may include one or more of the following major changes to the natural stream channel, all designed to increase the capacity of the channel: straightening, widening, and deepening; placement of a concrete invert and concrete sidewalls; and construction of culverts to carry the stream under roads and railroads as needed. In some instances, a completely new length of channel may be constructed so as to bypass a natural channel reach, as has been done for a portion of Underwood Creek in the City of Wauwatosa. The function of channel modifications or enclosures are to yield a lower, hydraulically more efficient waterway through which a given flood discharge can be conveyed at a much lower flood stage relative to that which would exist under natural or prechannelization conditions.

Modified channels, such as those shown in Figure 12, are detrimental to the support of fish and aquatic life for the following reasons:

1. They eliminate habitat areas needed by fish, aquatic insects, and benthic organisms. These habitat areas provide food, shelter, and spawning substrate necessary for the support of fish and other aquatic animals.

2. They eliminate plant substrate. Besides providing food, shelter, and spawning substrate for aquatic animals, aquatic plants provide oxygen to the water, remove nutrients, and trap sediments and other pollutants. Plants also provide shade, thereby lowering the temperature of the stream.

3. Some structures and dams provide barriers to the migration of fish and other aquatic animals, often necessary for feeding, spawning, and colonization purposes.

In addition, the aesthetic qualities of modified channels are generally poor, thereby reducing recreational use potential. Temporary storage of pollutants within the stream channel is also minimized, thereby increasing the first flush pollutant load effects on downstream receiving waters. These factors indicate that habitat improvement techniques, in addition to water pollution control measures, may need to be implemented to satisfy fish and aquatic life objectives within these channelized stream reaches.

The basic approach to improving the biological potential of a modified stream channel is to 1) provide protective areas where a suitable sediment substrate may at least temporarily accumulate; 2) increase vegetative growth; and 3) eliminate barriers to aquatic animal migration. Table 26 presents a description of selected measures which could be used to increase the biological potential of existing and future modified channels, and Figure 13 shows a sample design for a rehabilitated channelized stream section. In addition to providing suitable habitat for aquatic life, stream channel rehabilitation enhances the aesthetic qualities of the stream and—through temporary sediment storage, aeration, increased shading, and biological nutrient uptake—improves the water quality of the stream. It is recognized that most of these rehabilitation measures by their nature decrease the hydraulic efficiency of the stream channel. However, in many cases the hydraulic efficiency could be maintained at a level which would not preclude achievement of flood control design. A site-specific study would be required to determine the potential of each stream reach to provide biological habitat and at the same time be acceptable for flood control purposes.

Since techniques are available to rehabilitate channelized streams, the Commission considered classifying channelized stream reaches for warmwater or limited fishery and aquatic life use—as opposed to restricted use—if water quality standards could be achieved. Local study efforts should be carried out to determine the feasibility of these channel rehabilitation techniques in selected stream reaches, and to demonstrate the effectiveness of the techniques in providing for the support of a warmwater or limited fishery while not interfering significantly with the intended hydraulic performance of the modified channels.

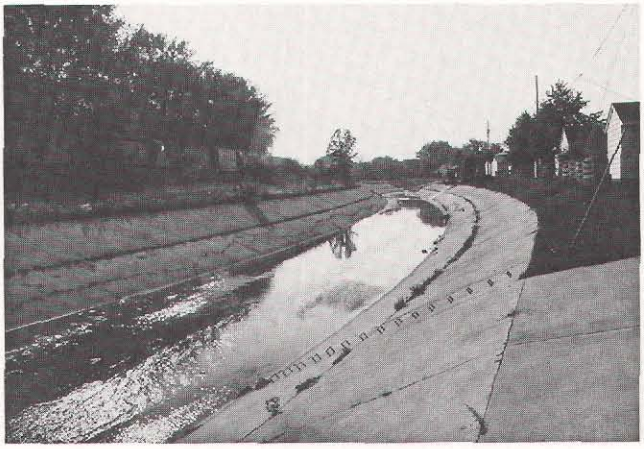
Figure 12

EXAMPLES OF EXISTING CHANNEL MODIFICATIONS IN THE MENOMONEE RIVER WATERSHED

MAJOR CHANNELIZATION ALONG UNDERWOOD CREEK IN THE CITY OF WAUWATOSA

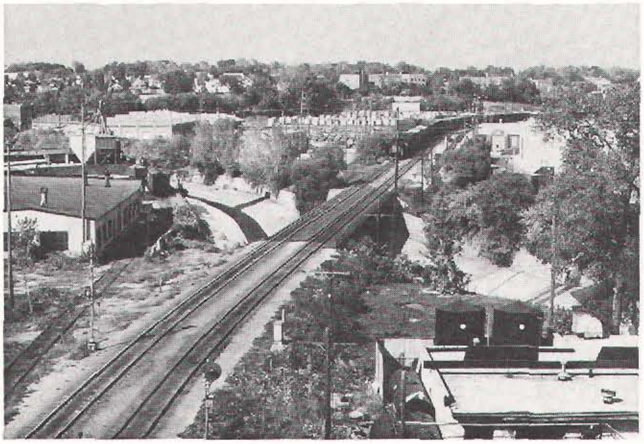
View from N. 115th Street Looking West (upstream)

View from Near 102nd Street and Fisher Parkway Looking West (upstream)

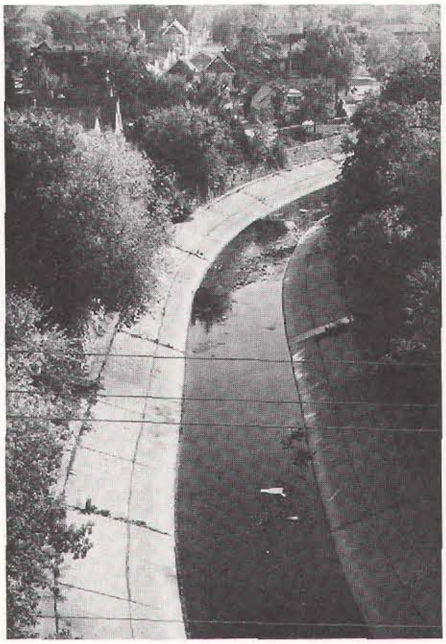


MAJOR CHANNELIZATION ALONG THE MENOMONEE RIVER IN THE CITY OF MILWAUKEE

View from Wisconsin Avenue Looking North (upstream)



View from Wisconsin Avenue Looking South (downstream)



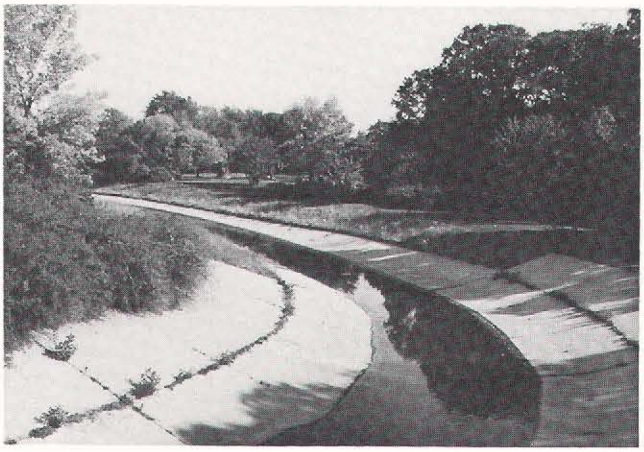
## NONPOINT SOURCE POLLUTION PRIORITY AREA ANALYSIS

To supplement the findings of the hydrologic-hydraulic-water quality simulation studies, identify potential high pollution areas, determine the relative urgency of implementing nonpoint source controls, provide for the most cost-effective development of practices and prioritize the initiation of project planning, a special analysis was conducted of both the rural and urban areas of the Region to identify spatial differences in nonpoint source pollution potential. The analysis identified subbasins as having a very high, high, moderate, low, or very low potential for diffuse pollutant contributions and thereby suggests priority areas for diffuse source control activities. The information derived from this analysis is useful in interpreting the model simulation of existing and probable future conditions, as well as in interpreting the

**Figure 12 (continued)**

MAJOR CHANNELIZATION ALONG HONEY CREEK IN THE CITY OF WAUWATOSA

View from Honey Creek Parkway Drive and St. Anne Court Looking Northwest (downstream)



View from Bluemound Road and St. Anne Court Looking Northwest (downstream)

*Source: SEWRPC.*

historic water quality analyses, which do not directly identify the sources of water pollution to the various streams and lakes in the Region.

Rural Pollution Priority Areas

The pollution potential of rural areas is dependent on soil type, slope, land use, and existing conservation practices. The criteria utilized for assignment of subbasin pollutant potential rankings are summarized in Table 27.

Rural subbasins with a very high potential designation characteristically have slopes of 4 to 6 percent and more than 50 percent of the area devoted to clean-tilled (row and vegetable) crops; slopes of 6 to 12 percent and more than 26 percent of the area devoted to clean-tilled crops; slopes of greater than 12 percent; or, as identified by local agriculturists and soil conservationists, have specific sites of known severe erosion problems requiring immediate application of nonpoint source controls. Rural subbasins with a high potential for diffuse source pollution characteristically have slopes of 4 to 6 percent and 26 to 50 percent of the area devoted to clean-tilled crops, or have slopes of 6 to 12 percent and less than 26 percent of the area devoted to clean-tilled crops. Subbasins with a moderate potential for diffuse source pollution characteristically have slopes of less than 4 percent and more than 50 percent of the area devoted to clean-tilled crops. Areas with a low potential for nonpoint source pollution may require a limited application of control practices and characteristically have slopes of less than 4 percent and 26 to 50 percent of the area devoted to clean-tilled crops, or have characteristic slopes of 4 to 6 percent and up to 26 percent of the area devoted to clean-tilled crops. Finally, rural areas with a very low potential for pollution problems characteristically have slopes of less than 4 percent and less than 26 percent of the area devoted to clean-tilled crops. Slopes and the percent of the land in clean-tilled crops are important in determining the pollution potential of a subbasin, since a slope of greater than 4 percent is commonly used as criterion for limited use of the land, and row and vegetable crops (clean-tilled cropland), as presented in SEWRPC Technical Report No. 21, contribute the majority of diffuse source pollutants originating from rural land. Rural subbasin pollution potential classifications were used to estimate areas which should be considered for an advanced level of agricultural land management treatment. Base-of-slope detention storage was applied to those subbasins with the highest potential for diffuse source pollution control problems when the need for a high degree of rural diffuse source pollution control was deemed necessary to meet water quality standards.

Table 26

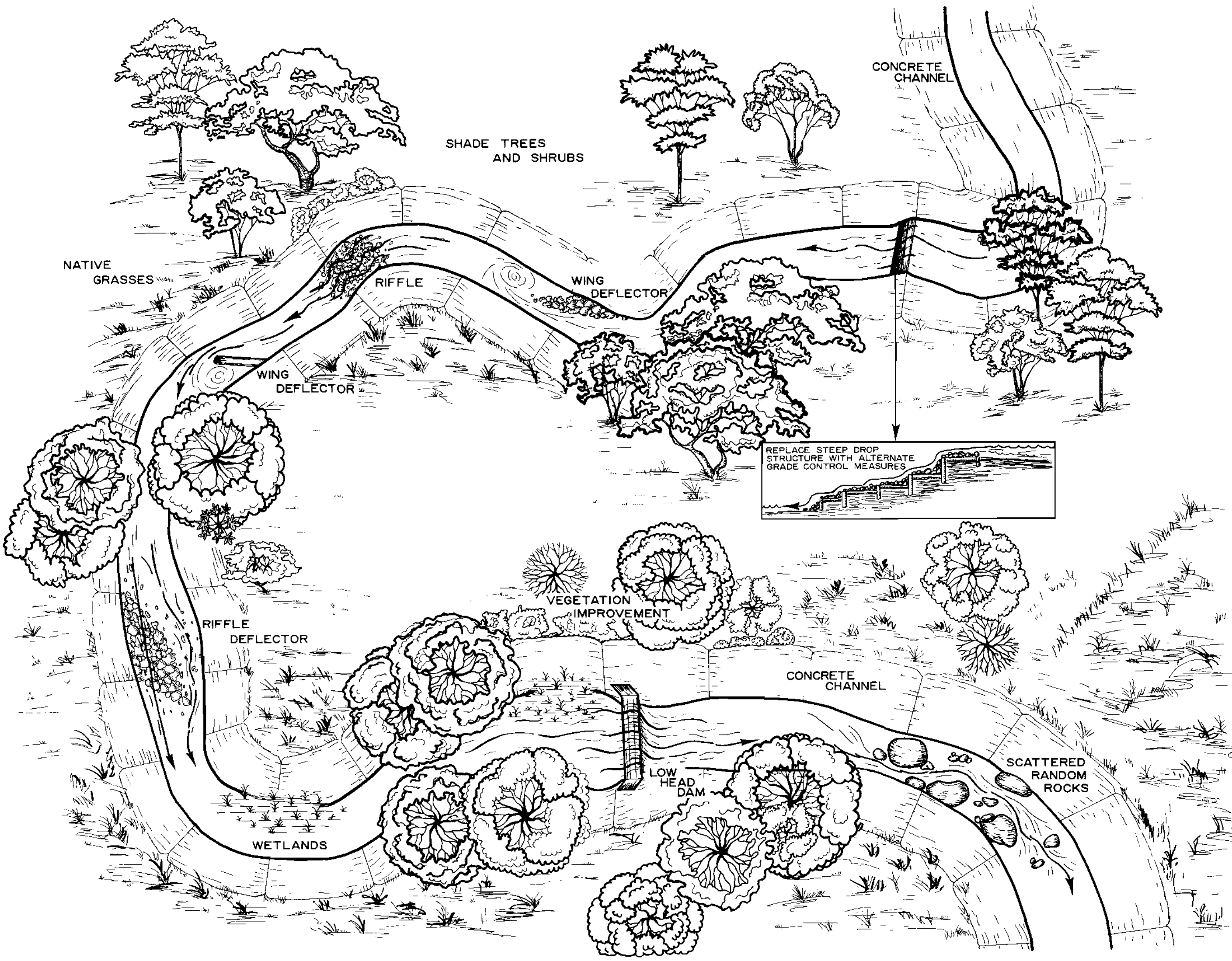
SELECTED BIOLOGICAL LIFE HABITAT REHABILITATION MEASURES FOR EXISTING AND PLANNED CHANNEL MODIFICATIONS

| Rehabilitation Measure | | Description and Application |
|---|---|---|
| Existing Modified Channels | Riffle and Pool Development | Use various methods below to create riffle-pool sequence. Riffles are sections of streams containing rocks, gravel, or other coarse substrate in which the current is swift enough to remove silt and sand. Riffles should occur at intervals equal to five to seven channel widths. A water depth of six inches is desirable. Riffles help aerate the stream and provide ideal biological habitat. Pools are deeper, slower sections of streams and provide valuable food and resting and refuge areas for fish. Pools ideally should be designed so that the sediments are not completely flushed out during storm events |
| | Installation of Low Gabion, Rock, or Concrete Check Dams | Low dams provide a pooling effect and accumulate sediment for biological habitat. Dams should be low enough to provide for fish migration |
| | Installation of Gabion or Rock Wing Deflectors | Wing defectors provide a riffle-pool effect and accumulate sediment. They provide cover for fish and other aquatic life |
| | Use of Scattered Rocks | Installation of rocks create a riffle effect and provide cover for fish and other aquatic life. They also temporarily trap some sediment |
| | Vegetation Improvement | Plant erosion-resistant native grasses, shrubs, and trees as close as practical to the stream channel to provide cover, food supply, and shade. Provide buffer strip along channel |
| | Removal of Barriers to Migrating Species | Remove dams, drop structures, chutes, and steep grades which cannot be crossed by migrating fish and other aquatic life. Construct alternative grade control structures |
| Planned Modified Channels | Channel Section and Grade Design | The low flow channel cross-section should approach a natural stream condition. The bottom width of the channel and the channel grade can be varied to create a riffle-pool sequence |
| | Avoidance of Straight Channels | Constructed channels should be aligned as much as possible with the natural stream curvature |
| | Vegetation and Wetland Preservation | Preserve native vegetation and wetlands as much as possible to provide shade trees and shrubs and maintain the water quaity, environmental, and aesthetic benefits of wetlands |
| | Installation of Channel Bank Reservoirs | Various storage measures may be incorporated into the channel bank design to temporarily store runoff, reduce size requirements for downstream channels, and accumulate sediment, thereby providing suitable biological habitat |
| | Avoidance of Barriers to Migrating Species | Do not construct steep drop structures which cannot be crossed by fish or other aquatic life |
| | Use of Construction Erosion Controls | Construction erosion controls are essential for channel modification projects. Stabilize the exposed surface, control runoff, and prevent sediment delivery to the stream |

*Source: SEWRPC.*

Figure 13

SELECTED BIOLOGICAL HABITAT REHABILITATION TECHNIQUES FOR CHANNELIZED STREAMS




*Source: SEWRPC.*

Table 27

NONPOINT SOURCE POLLUTION POTENTIAL DESIGNATION CRITERIA FOR RURAL AREAS

| Characteristic Slope of Subbasin [a] | Percent of Subbasin Area Devoted to Row and Vegetable Crops[a] | | |
|---|---|---|---|
| | Greater than 50 Percent | 26 Percent - 50 Percent | Less than 26 Percent |
| Greater than 12 percent . . . . | Very High | Very High | Very High |
| 6 - 12 percent. . . . . . . . . . . | Very High | Very High | High |
| 4 - 6 percent. . . . . . . . . . . . | Very High | High | Low |
| Less than 4 percent . . . . . . . | Moderate | Low | Very Low |

[a] *Areas with known severe erosion problems as identified in the Commission rural land management practice survey by local officials and farmers were also given a very high designation regardless of other characteristics of the subbasin.*

*Source: SEWRPC.*

In addition, livestock operations were classified as to their potential for causing water pollution problems and the urgency and methods for controlling pollutant runoff from these operations. Animal herds consisting of less than 25 equivalent animal units were generally considered not to represent major long-term problems in the Region. Operations with greater than 25 equivalent animal units and located more than 500 feet from a major drainageway or continuous surface water were classified as having low potential for causing pollution problems. Operations with greater than 25 equivalent animal units and located less than 500 feet from a major drainageway or continuous surface water and on slopes of less than 2 percent were classified as having a moderate potential for causing pollution problems. Operations with greater than 25 equivalent animal units and located less than 500 feet from a major drainageway and on slopes of greater than 2 percent were identified as critical pollution sources. For costing purposes, manure storage facilities were generally recommended for critical livestock pollution sources located in subbasins of very high or high potential, although the actual implementation of livestock waste control measures requires detailed planning efforts and water quality evaluation. A distance of 500 feet from a surface water has been identified in studies as reducing livestock pollution runoff by at least 90 percent. Areas of greater than 2 percent slope often require some form of land management practice and are susceptible to erosion problems.

Also presented in the rural priority pollution problem analyses are subbasin designations for the level of conservation practice measures implemented since 1964. Subbasins with more than 20 conservation practices were identified as having a high level of current control; subbasins with six to 20 conservation practices were identified as having a moderate level of current control; and subbasins with less than six conservation practices were designated as having a low level of control.

Urban Pollution Priority Areas

The prioritization of the pollution potential of urban areas is more complex than that for rural areas, due to the numerous cultural alterations which overshadow the effects of the physical characteristics of the land surface. Accordingly, an Urban Pollution Potential Index (UPPI) was developed to systematically analyze the expected water quality effects of various urban land uses and activities.

It has been shown that the most important variables affecting pollutant loads from urban areas are generally the proportion of industrial, open, and transportation land uses, the storm sewer characteristics, and the physical and environmental condition of the housing and adjoining land.[8] In addition, the type of sanitary sewage disposal system utilized, the land slope, the percent of the land which is impervious, and the stream density all influence urban diffuse source pollutant loads. These criteria were allocated UPPI "points" to allow for the comparison of urban subbasins. The decision of what level, or magnitude, of any criteria would constitute a high, moderate, or low pollution potential was made following a sample application of the index in the Region, which was designed to provide a reasonable distribution of the three pollution priority categories for each criteria. The urban pollution priority criteria and the UPPI point allocations are presented in Table 28. The following criteria were considered in the evaluation of urban pollution potential.

Land Use: Industrial and transportation land use activities, along with construction activities, contribute the highest unit-area pollutant loads to surface waters. The presence and magnitude of these activities are therefore indicative of the pollution potential of a subbasin. A high proportion of open or unused land would also increase the pollution potential of a subbasin, since such lands are likely to be subjected to construction activities and are often sites of refuse accumulation and soil erosion.

Impervious Area: The proportion of a subbasin which is impervious affects water quality. As the percent impervious area increases, pollution potential increases, due to increased human activity, debris accumulation, the destruction or disturbance of vegetation, and increased storm water runoff rates.

Exterior Housing Condition: The Commission, in an effort to provide insight into the physical condition of housing units, conducted an exterior condition survey of more than 15,000 housing units throughout the Region in 1972. Each housing unit in the sample was observed and the unit rated according to the number of "defect points" assigned. Defect points were assigned for the condition of such structural elements as foundation, exterior walls, roof, chimney, gutter, downspouts, siding, windows, doors, and porch; the need for painting or repair; accumulated debris; and the condition of nearby buildings and the immediate neighborhood. Housing units in poor physical condition tend to contribute more pollutants to storm water runoff.

Storm Sewer Service: Subbasins served by properly installed and maintained surface drainage systems with channels lined with pervious material have a lower potential for pollution than channels lined with impervious materials. Pervious channel linings slow runoff and increase infiltration and plant uptake of nutrients. A subbasin served by a storm drainage system consisting mainly of subsurface conduits and impervious-lined channels has a relatively higher pollution potential since nearly all pollutants carried in the increased runoff will be transported through the storm drainage system to the stream. If only a portion of a subbasin is served by an impervious storm sewer, a moderate pollution potential is indicated.

Sanitary Sewer Service: Privately owned onsite sewage disposal systems, especially if located on unsuitable soils or if improperly installed or maintained, have a high potential for contributing to surface water pollution.

[8] *AVCO Economic Systems Corporation, Stormwater Pollution from Urban Land Activity, 1970.*

Table 28

NONPOINT SOURCE POLLUTION POTENTIAL DESIGNATION CRITERIA FOR URBAN AREAS

| Urban Criteria[a] | Unit | Index Rating Category for Specific Criteria[b] | | |
|---|---|---|---|---|
| | | Low | Moderate | High |
| Percent Subbasin Industrial Land . . . . . . | Percent | Less than 6 | 6-25 | More than 25 |
| Percent Subbasin Open Land . . . . . . . . . | Percent | Less than 10 | 10-50 | More than 50 |
| Percent Subbasin Transportation Land . . | Percent | Less than 10 | 10-25 | More than 25 |
| Percent Subbasin Impervious . . . . . . . . . | Percent | Less than 30 | 30-48 | More than 48 |
| Exterior Housing Condition. . . . . . . . . . | Defect Points[c] | Less than 4 | 4-10 | More than 10 |
| Storm Water Drainage System Type . . . . | -- | Surface drainage-pervious material channels | Portions of subbasin served by storm water management systems with subsurface conduits and impervious material channels | Storm water management drainage system-subsurface conduits and impervious material channels |
| Method of Sewage Disposal . . . . . . . . . . | -- | Sanitary sewer service | Portions of subbasin served by sanitary sewer service | Onsite sewage disposal systems |
| Land Slope. . . . . . . . . . . . . . . . . . . . . . | Percent | Less than 2 | 2-4 | More than 4 |
| Stream Density (stream length per unit area subbasin) . . . . . . . . . . . . | Feet per Acre | Less than 5 | 5-10 | More than 10 |

[a] *These criteria are applied to subbasins in the Region which contain significant amounts of urban land.*

[b] *Criteria points are allocated as follows, and summed to provide a subbasin rating:*

| | Pollution Potential | | |
|---|---|---|---|
| | *Low* | *Moderate* | *High* |
| *points* | *0* | *1* | *2* |

[c] *The exterior housing condition is determined by the average number of defect points assigned to each surveyed housing unit in the subbasin during the Commission's exterior housing condition survey conducted in 1972.*

*Source: SEWRPC.*

The provision of sanitary sewer service will decrease the potential for sanitary waste discharges. If only part of a subbasin is served by sanitary sewers, a moderate pollution potential is assigned.

Land Slope: Pollution potential increases with slope since the amount and rate of storm water runoff and transported pollutants is greater for land areas with higher slopes. A slope of 2 percent or more is commonly used as an indicator of the need for soil erosion controls.

Stream Density: Stream density was selected as a measure of pollution potential since areas nearest streams are most likely to contribute pollutants to the stream. A subbasin with a high stream density would have a larger proportion of its land area close to the stream.

Urban Pollution Potential Classification

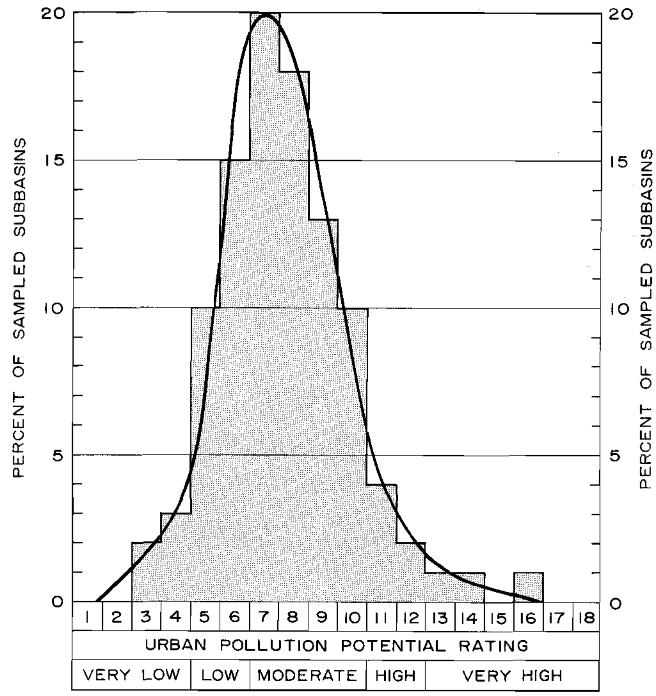
Using the criteria discussed above, the Commission identified categories of relative urgency for nonpoint source pollution control. The categories serve to simplify the continuum of the numeric rankings, and provide a parallel to the five categories of rural nonpoint source pollution potential. To develop these categories, a trial application, or sample analysis, of the UPPI was compared to a SEWRPC staff ranking of the relative nonpoint source pollution potential of 279 hydrologic subbasins located in several trial application areas selected to represent a wide range of pollution potential conditions. The staff ranking was based on a working familiarity with the technical literature pertaining to nonpoint pollution, knowledge about historic water quality conditions in the Region as derived from the Commission continuing water quality monitoring program, application of the water quality simulation model, and attendant pollution source inventory data. The trial applications included areas representative of relatively high potential for pollution, such as the Menomonee Industrial Valley in Milwaukee and portions of the Kinnickinnic River watershed, and areas representative of relatively low potential for pollution, namely the Village of Mukwonago and the Village of River Hills. The high level of industrial and transportation land use activities in the Menomonee Valley can be expected to contribute high pollutant loads to surface water drainage systems. The Village of Mukwonago, by contrast, is an example of a well-maintained small community, largely residential in nature and tributary to the Mukwonago River which, based on existing water quality data and model simulations, is one of the cleanest streams within the Region draining any significant proportion of urban residential area. The Village of River Hills provides an example of a suburban, low-density, residential area with large lots, but served by a sanitary sewerage system. Other sample analysis areas included portions of the Region—such as part of the City of Milwaukee and the City of West Bend—considered to be representative of a moderate or typical pollution potential.

Figure 14 presents the results of the initial analysis based on this trial application of the urban pollution potential index, depicting the relationship of the computed UPPI for each subbasin to the overall distribution. The trial subbasins exhibited UPPI values ranging from 3 to 16, with a mean of about 8 and a median of 7. Since 3 percent of the values exceeded 12 and 4 percent of the values were less than 5, these two limits were selected as the lower limit of the highest potential category and the upper limit of the lowest category, respectively. For the remaining middle range, as set forth in Figure 14, about 52 percent of the trial subbasins were clustered within one point of the mean. Therefore, a central range of 7 to 10 was selected, leaving two more "intermediate" categories. The resulting five categories for urban potential pollution index classification are set forth in Table 29.

Pollution potential maps and discussions are presented for each watershed in this chapter. The results of the Commission assessment of existing water quality conditions are also presented for each watershed. These water quality conditions, as designated from the Commission's water quality index, reported in Volume One, Chapter IV of this report, are rated as poor, fair, good, or excellent. Also presented are designations of which water quality standards are met or violated under simulated existing conditions. Fundamental to the above application and use of the urban and rural pollution potential criteria is the target percentage of diffuse source pollution reduction required to meet recommended water quality use objectives and supporting standards under existing conditions for each subbasin, as determined by the water quality simulation analyses.

Figure 14

DISTRIBUTION OF URBAN POLLUTION POTENTIAL INDEX NUMERIC RANKINGS FOR SAMPLED HYDROLOGIC SUBBASINS IN SOUTHEASTERN WISCONSIN




[a] DISTRIBUTION AND CLASSIFICATION BASED ON THE ANALYSIS OF 279 SUBBASINS.

*Source: SEWRPC.*

Table 29

URBAN POLLUTION POTENTIAL CLASSIFICATION

| Pollution Potential Classification | Urban Pollution Potential Index |
|---|---|
| Very High | 13-18 |
| High | 11-12 |
| Moderate | 7-10 |
| Low | 5-6 |
| Very Low | 0-4 |

*Source: SEWRPC.*

## INLAND LAKE WATER QUALITY ANALYSES AND EVALUATION OF PLAN ALTERNATIVES

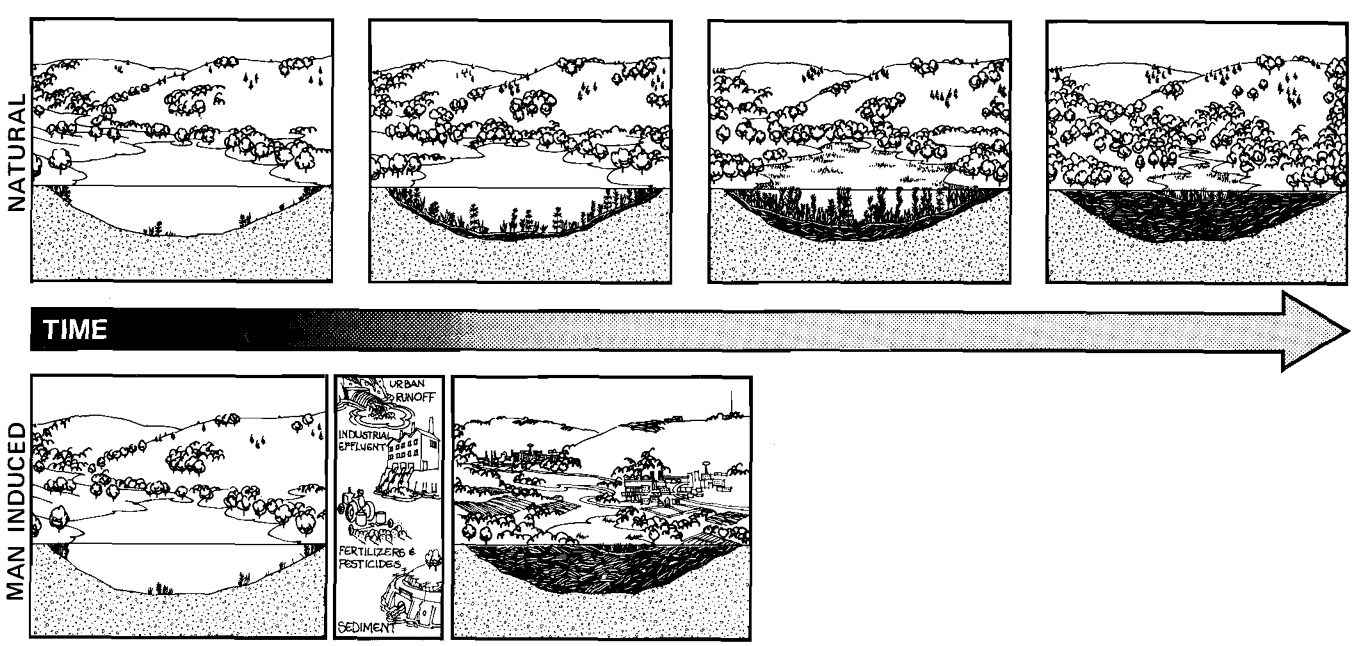
The 100 major lakes—lakes of 50 acres or more in size—and numerous smaller lakes in southeastern Wisconsin have been subjected to increased pollutant loadings as a result of the physical development of the Region. Because lakes characteristically "store" or accumulate pollutants, they are more susceptible to water quality problems than are streams, and the cumulative effects of malfunctioning septic tank systems, livestock waste contributions, urban and rural runoff, and other diffuse pollution sources are often manifested in algae blooms, excessive aquatic weed growth, fish kills, undesirable forms of fish life, and damage to benthic communities. These manifestations of pollution in turn affect recreational uses of and land values around the lakes.

Lake water quality problems are generally directly or indirectly caused by the increased fertility of lakes, a process referred to as eutrophication. Technically speaking, eutrophication and water quality deterioration are not synonomous. Eutrophication is a natural process and all lakes "age" through time—generally accompanied by increased productivity and increased sedimentation. Natural eutrophication, however, is a very slow process, as evidenced by the apparent healthy and generally oligotrophic or mesotrophic—young or middle-aged—condition of relatively undisturbed lakes in the Region after approximately 10,000 years of natural eutrophication.[9] As shown in Figure 15, however, the effects of man-made modifications can greatly accelerate the eutrophication rate.

[9] *Most lakes in southeastern Wisconsin were formed when the most recent continental glaciers, those of the Wisconsin glaciation period, receded from the area, leaving imbedded ice blocks, or kettle holes, and a disrupted drainage pattern behind. The glaciers are believed to have receded from southeastern Wisconsin approximately 10,000 years ago.*

**Figure 15**

**COMPARISON OF THE RELATIVE RATE OF LAKE EUTROPHICATION UNDER NATURAL AND MAN-INDUCED CONDITIONS**




*Source: S. M. Born and D. A. Yanggen. Understanding Lakes and Lake Problems, Inland Lake Demonstration Project, Upper Great Lakes Regional Commission, 1972.*

Water quality is generally defined in terms of water use objectives and supporting water quality standards, and even eutrophic lakes may have "good" water quality in that they may support abundant fish populations and high-quality recreational activities. This distinction between natural and cultural eutrophication is important, since surface waters—including lakes—should generally achieve water quality suitable for recreational use and for the maintenance of fish and aquatic life if technically and economically feasible and if such achievement is not precluded by natural conditions. Some lakes in the Region are naturally limited and unable to accommodate certain water uses even under undisturbed conditions. The areawide water quality management plan should result in actions to achieve the proposed water quality objectives by preserving the lakes presently in good condition, and by enhancing the degraded water quality of other lakes—except those naturally use limited—which do not satisfy the objectives at the present time. A systems level plan can present alternative solutions for lake water quality problems, but local planning and implementation efforts are necessary to design the detailed "plan" for each lake. A certain minimum level of diffuse source control is universally recommended for all lakes, however, in order to ensure that basic water quality goals are achieved for each lake.

While significant advances have been made in the state-of-the-art of lake management, refinements and further research will enhance the technical basis needed for plan implementation. In particular, the widespread implementation of lake management measures will require additional investigation and documentation of nutrient loading criteria or limits, and of lake rehabilitation techniques.

Nutrient Loading Criteria

Because of the complexity and dynamic nature of nutrient pollution affecting lake water quality, detailed lake studies are required in order to thoroughly describe and fully understand such pollution. Methodologies have been developed, however, which may be used to indicate what level of pollutant loading can be tolerated by a lake before excessive aquatic plant growth occurs. Many studies—including detailed studies of 20 lakes in the Region conducted by the Commission and the Wisconsin Department of Natural Resources—have indicated that phosphorus is most often the nutrient which limits aquatic plant growth in southeastern Wisconsin lakes. A study of Madison, Wisconsin lakes[10] concluded that nuisance aquatic plant growth would occur if inorganic phosphorus and inorganic nitrogen concentrations exceeded 0.01 mg/l and 0.3 mg/l, respectively, during spring overturn. The total annual phosphorus load, however, is the most common criterion used in lake pollution studies in Wisconsin since nitrogen seldom limits plant growth and is freely available to lakes from natural sources and nitrogen fixation from the atmosphere by certain bacteria and algae. Another study substantiated the critical values of the above-mentioned study and developed total annual phosphorus loading criteria per unit of lake surface area as a function of the mean depth of the lake.[11] Further refinements of this development expressed the critical total phosphorus load as a function of mean depth and lake flushing rate, expressing a critical load which corresponded to an inlake concentration of about 0.02 mg/l total phosphorus during spring overturn.[12] The use of total phosphorus concentrations as a water quality standard provides results similar to those when using annual phosphorus loading criteria, since total phosphorus concentrations, as estimated herein, are directly proportional to the annual phosphorus load.

Table 30 summarizes the maximum total phosphorus concentration criteria associated with foor different combinations of water use objectives as set forth in Chapter II of this volume. The achievement of these concentrations is the goal of pollutant control strategies in the inland lake water quality analyses and in the plan alternatives.

Table 30

RECOMMENDED LAKE WATER USE OBJECTIVES AND CORRESPONDING TOTAL PHOSPHORUS CONCENTRATION STANDARDS

| Water Use Objectives | Maximum Total Phosphorus Concentration (mg/l) at Spring Overturn |
|---|---|
| Trout Fishery and Aquatic Life, Recreational Use, and Minimum Standards. . . . . . . . . . . . | 0.02 |
| Warmwater Fishery and Aquatic Life Recreational Use, and Minimum Standards. . . . . . . . . . . . | 0.02 |
| Warmwater Fishery and Aquatic Life, Limited Recreational Use, and Minimum Standards . . . . . . . . . | --[a] |
| Limited Fishery and Aquatic Life, Limited Recreational Use, and Minimum Standards . . . . . . . . . | --[a] |

[a] *Although no phosphorus standard is recommended for these water use objectives, reducing phosphorus loads will reduce the severity, extent, and duration of water quality problems. Therefore, sound land management practices for phosphorus control are recommended for lakes classified for limited recreational use.*

*Source: SEWRPC.*

[10] *Clair N. Sawyer, Fertilization of Lakes by Agricultural and Urban Drainage. J. New Engl. Waste Works Association, 51:109-127, 1947.*

[11] *Richard A. Vollenweider, Scientific Fundamentals of the Eutrophication of Lakes and Flowing Waters, with Particular Reference to Nitrogen and Phosphorus as Factors in Eutrophication. Organization for Economic Cooperation and Development, Director for Scientific Affairs (DAS/CSI/68.27) Paris, France, 1968.*

[12] *Richard A. Vollenweider and P. J. Dillon, The Application of Phosphorus Loading Concept to Eutrophication Research, N.R.C. Technical Report 13690: 1975.*

The hydrologic-hydraulic-water quality simulation model utilized as an analytical tool in the areawide water quality management planning program provides estimates of phosphate phorphorus—as opposed to total phosphorus—concentrations for all flow-through and headwater lakes in the Region. When derived from a properly calibrated model, total phosphorus concentrations during spring overturn can be estimated from simulated phosphate-phosphorus concentrations and be directly compared to the total phosphorus standards set forth in Table 30 to determine whether the lake water quality exceeds the standards and what level of phosphorus loading reduction, if any, is necessary to satisfy the standards. It was initially intended that the calibration data collected for the 20 lakes studied under the areawide water quality management program could be extrapolated to the remaining 80 major lakes in the Region. However, subsequent analyses indicated that the water quality of lakes for which adequate calibration data were lacking were poorly simulated. Moreover, the collection of such data for all major lakes was beyond the scope of the initial planning program. Accordingly, the Commission sought a procedure to estimate nutrient concentrations in lakes which could utilize existing inventory data, provide a reasonably accurate indication of existing water quality, predict the probable effects of reduced nutrient inputs to lakes, and compare to an accepted water quality criterion. Such a procedure, which was reported by Dillon and Rigler[13] and is described below, was utilized for lakes where suitable model calibration data were lacking. The inland lake water quality analyses also incorporated the findings of the previously mentioned special lake water quality monitoring and analysis program presently being conducted for 20 lakes as part of the areawide water quality management planning program in coordination with the Wisconsin Department of Natural Resources inland lake renewal and water quality research programs. Available results from these special lake studies have been incorporated into the analysis included in this chapter, as well as into the computer simulation analyses of properly calibrated lakes. The data sources available for all major lakes existing within the Region are indicated in Table 31.

Thus, methods to estimate a total phosphorus concentration—thereby permitting use of a total phosphorus criterion—were investigated. Dillon and Rigler determined that the steady-state total phosphorus concentration for a flow-through or headwater lake during spring overturn could be estimated by:

$$[P] = \frac{L(1-R)}{\bar{z}\ p}$$

where:

[P] represents the total phosphorus concentration during spring overturn; mg/l

L represents the unit area loading of total phosphorus; grams/meter$^2$/year

$\bar{z}$ represents the mean depth; meters

p represents the flushing rate of the water in the lake, as $\frac{1}{\text{hydraulic residence time}}$; per year

R represents the fraction of total phosphorus loading retained in the lake, estimated by:

$$R = 0.426\ e^{(-0.271\ qs)} + 0.574 e^{(-0.00949\ qs)}$$

where:

qs represents areal water loading to lake; meters/year

e represents the base of the system of natural logrithms having the approximate numerical value 2.71828.

The steady-state total phosphorus concentration and the required level of diffuse source pollution reductions can be estimated for flow-through and headwater lakes as shown below in a sample computation for Cross Lake in Kenosha County:

Sample Application: Flow-through or Headwater Lakes—Cross Lake

$$[P] = \frac{L(1-R)}{\bar{z}\ p}$$

$$L = \frac{490 \text{ lbs}}{87 \text{ acres}} = \frac{222{,}460 \text{ grams}}{352{,}089 \text{ meter}^2} = 0.632 \text{ grams per meter}^2 \text{ per year}$$

$\bar{z}$ = 3.6 meters

p = 0.474 times per year

$$R = 0.426\ e^{(-0.271\ qs)} + 0.574\ e^{(-0.00949\ qs)}$$

$$qs = \frac{599{,}815 \text{ meter}^3 \text{ per year input}}{352{,}089 \text{ meter}^2} = 1.703 \text{ meters per year}$$

R = 0.833

$$[P] = \frac{0.632\ (1-0.833)}{3.6\ (0.474)} = 0.062 \text{ mg/l total phosphorus}$$

Required Nonpoint Source Control: Total Phosphorus Standard - 0.02 mg/l

Therefore, required nonpoint source control =

$$1- \left(\frac{\text{Phosphorus Standard}}{\text{Lake Phosphorus Concentration}}\right)$$

$$= 1 - \left(\frac{0.02}{0.062}\right)$$

= 68 percent

[13] *P. J. Dillon and F. H. Rigler, A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status. J. Fish. Res. Board Can. 32: 1519-1531. September 1975.*

Table 31

AVAILABLE DATA SOURCES FOR THE ANALYSES OF 100 MAJOR LAKES IN SOUTHEASTERN WISCONSIN

| Watershed and Lake | Available Data Sources | | | |
|---|---|---|---|---|
| | Calculation Using Dillon and Rigler Method | Calibrated Water Quality Model Simulation | Uncalibrated Water Quality Simulation | Detailed Lake Study |
| Des Plaines River Watershed | | | | |
| George | X | | X | X |
| Hooker | X | | X | |
| Paddock | X | | X | X |
| Shangrila/Benet | X | | | |
| Fox River Watershed | | | | |
| Army | X | | | |
| Benedict | X | | X | |
| Beulah | X | | X | |
| Big Muskego | X | | X | |
| Bohner | X | | X | |
| Booth | X | | | |
| Browns | X | | X | |
| Buena | X | | X | |
| Camp | X | | X | |
| Center | X | | | |
| Como | X | | X | X |
| Cross | X | | | |
| Denoon | X | | X | |
| Dyer | X | | X | |
| Eagle | X | X | | X |
| Eagle Spring | X | | X | |
| Echo | X | | X | |
| Elizabeth | X | | X | X |
| Geneva | X | X | | X |
| Green | X | | X | |
| Kee Nong Go Mong | X | | X | |
| Lilly | X | | | |
| Little Muskego | X | | X | |
| Long | X | | X | |
| Lower Phantom | X | | X | |
| Lulu | X | | X | |
| Marie | X | | X | X |
| Middle | X | | X | |
| Mill | X | | X | |
| North | X | | X | |
| Pell | X | | X | |
| Peters | X | | | |
| Pewaukee | X | X | | X |
| Pleasant | X | | X | |
| Potters | X | | X | X |
| Powers | X | | X | |
| Saylesville Mill Pond | X | | X | |
| Silver (Kenosha County) | X | | | |
| Silver (Walworth County) | X | | X | |
| Spring | X | | X | |
| Tichigan | X | | X | |
| Upper Phantom | X | | X | |
| Voltz | X | | | |
| Wandawega | X | | | X |
| Waubeesee | X | | X | |
| Wind | X | | X | |

Table 31 (continued)

| Watershed and Lake | Available Data Sources: Calculation Using Dillon and Rigler Method | Calibrated Water Quality Model Simulation | Uncalibrated Water Quality Simulation | Detailed Lake Study |
|---|---|---|---|---|
| Milwaukee River Watershed | | | | |
| Barton Pond | X | | X | |
| Big Cedar | X | X | | X |
| Green | X | | | |
| Little Cedar | X | X | | X |
| Lucas | X | | X | |
| Mud | X | | | |
| Silver | X | X | | X |
| Smith | X | | | |
| Spring | X | | | |
| Twelve | X | | X | |
| Wallace | X | | | |
| West Bend Pond | X | | X | |
| Rock River Watershed | | | | |
| Ashippun | X | | | X |
| Bark | X | | X | |
| Beaver | X | | | |
| Comus | X | | X | |
| Cravath | X | | | |
| Crooked | X | | X | |
| Delavan | X | | X | |
| Druid | X | | | |
| Five | X | | | |
| Fowler | X | | | |
| Friess | X | | | X |
| Golden | X | | | |
| Hunters | X | | X | |
| Keesus | X | | | |
| LaGrange | X | | | |
| Lac La Belle | X | | | X |
| Loraine | X | | | |
| Lower Genesee | X | | | |
| Lower Nashotah | X | | X | |
| Lower Nemahbin | X | | X | |
| Middle Genesee | X | | | |
| Moose | X | | | |
| Nagawicka | X | | X | |
| North | X | | | X |
| Oconomowoc | X | | | X |
| Okauchee | X | | | X |
| Pike | X | X | | X |
| Pine | X | | | |
| Pretty | X | | | |
| Rice | X | | | |
| School Section | X | | X | |
| Silver | X | | | |
| Tripp | X | | | |
| Turtle | X | | X | |
| Upper Nashotah | X | | X | |
| Upper Nemahbin | X | | X | |
| Waterville Pond | X | | X | |
| Whitewater | X | | | |

*Source: SEWRPC.*

For a landlocked lake without an outlet, however, R would equal 1.0 and the above equation could not be used. An alternative equation for estimating total phosphorus concentrations, as described by Dillon and Rigler,[14] would be:

$$[P] = \frac{L}{\bar{z}\,(\sigma + p)}$$

where:

$\sigma$ = sedimentation rate, estimated by $\frac{10}{\bar{z}}$; per year

A sample application for landlocked lakes is shown below for Peters Lake in Walworth County:

Sample Application: Landlocked Lakes—Peters Lake

$$[P] = \frac{L}{\bar{z}\,(\sigma + p)}$$

$$L = \frac{761 \text{ lbs.}}{64 \text{ acres}} = \frac{345{,}500 \text{ grams}}{259{,}008 \text{ meter}^2} = 1.33 \text{ grams per meter}^2 \text{ per year}$$

$$\bar{z} = 0.91 \text{ meter}$$

$$\sigma = \frac{10}{0.91} = 10.99 \text{ per year}$$

$$p = 6.70 \text{ times per year}$$

$$[P] = \frac{1.33}{0.91\,(10.99 + 6.70)} = 0.08 \text{ mg/l total phosphorus}$$

Required Nonpoint Source Control: Total phosphorus standard—0.02 mg/l.

$$1 - \left(\frac{\text{Phosphorus Standard}}{\text{Lake Phosphorus Concentration}}\right)$$

$$= 1 - \frac{0.02}{0.08}$$

$$= 75 \text{ percent}$$

Estimates of total phosphorus concentrations, provided in Appendix C, are determined by either the methodology indicated above or by simulation modeling, for all lakes over 50 acres in size in the Region, under existing and plan year 2000 land use conditions. The required level of nonpoint source control is also indicated as calculated by either the methodology described above or by simulation modeling.

[14] *Ibid.*

As noted previously, the Dillon and Rigler method of calculating the expected total phosphorus concentration during spring overturn and the desired degree of phosphorus source control was utilized as an alternative to the hydrologic-hydraulic-water quality model simulation method when adequate lake sampling data were not available for satisfactory model calibration. A comparison and analysis of the results of these two alternative methods of evaluating lake phosphorus conditions for lakes which had been simulated and for which suitable calibration data were available are presented in Table 32. This comparison indicates that the two methods yield similar results. Therefore, if sufficient calibration data were available, the water quality simulated data were used for the plan analyses; if calibration data were not available, the Dillon and Rigler method described above was used. In all cases where detailed lake study reports were available, those reports were also used in assessing needs and alternative control measures for the lake.

Lake Rehabilitation Techniques

Although preventing further deterioration, the reduction of nutrient inputs to lakes in southeastern Wisconsin will not necessarily result in the elimination of existing water quality problems. In eutrophic lakes, especially in the presence of continued mixing or an anaerobic hypolimnion (the lower layer of a stratified lake), significant amounts of phosphorus may continue to be released from the sediments to the overlying water column. Furthermore, macrophytes (weeds) may continue to grow prolifically in nutrient-rich bottom sediments, regardless of the nutrient content of the overlying water. The previously described models for estimating total phosphorus concentrations developed by Dillon and Rigler do not take these factors into account, and in many lakes of the Region, the indicated water quality improvements expected from a reduced nutrient input will be inhibited or prevented by these conditions. If this occurs, or if other characteristics of a lake result in restricted water use potential, the application of lake rehabilitation techniques should be considered.

The applicability of specific lake rehabilitation techniques is highly dependent on lake characteristics. Figure 16 shows the relationship between lake characteristics and lake rehabilitation techniques potentially applicable in southeastern Wisconsin. The success of any lake rehabilitation technique can seldom be guaranteed since the state-of-the-art is still in the very early stages of development. Because of the relatively high cost of applying most techniques, a cautious approach to implementing lake rehabilitation techniques is desirable, with the widespread use of any technique being contigent on further actual experience in the field. Lake rehabilitation techniques should be applied first to lakes in which: 1) nutrient inputs to the lake have been reduced to below the critical level; 2) there is the greatest probability of

Table 32

COMPARISON OF SPRING TOTAL PHOSPHORUS CONCENTRATIONS ESTIMATED BY THE WATER QUALITY SIMULATION MODEL AND BY THE DILLON AND RIGLER METHOD TO TOTAL PHOSPHORUS CONCENTRATIONS MEASURED IN 1976 FOR CALIBRATED LAKES

| Lake | Watershed | Spring Total Phosphorus Concentration (mg/l) | | |
|---|---|---|---|---|
| | | Measured 1976[a] | Simulation Model[b] | Dillon and Rigler Method |
| Big Cedar. . . . . . . . . | Milwaukee River | 0.04 | 0.11 | 0.07 |
| Eagle. . . . . . . . . . . . | Fox River | 0.05 | 0.11 | 0.10 |
| Geneva . . . . . . . . . . | Fox River | 0.03 | 0.06 | 0.04 |
| Little Cedar . . . . . . . | Milwaukee River | 0.05 | 0.09 | 0.05 |
| Pewaukee. . . . . . . . . | Fox River | 0.07 | 0.09 | 0.12 |
| Pike . . . . . . . . . . . . | Rock River | 0.02 | 0.05 | 0.18 |
| Silver . . . . . . . . . . . | Milwaukee River | 0.02 | 0.11 | 0.08 |

[a] *The study year 1976 received below average precipitation. Hence, the values shown represent a dry year condition, whereas the simulation model and Dillon and Rigler method values represent an average year condition.*

[b] *The water quality model simulates phosphate-phosphorus, not total phosphorus. Simulated phosphate-phosphorus values were multiplied by a factor of two to estimate total phosphorus concentrations.*

*Source: SEWRPC.*

success based upon the results of the studies recommended below to be conducted prior to implementing a lake rehabilitation program; and 3) the possibility of adverse environmental impacts is minimal.

Lake rehabilitation techniques that are applicable to southeastern Wisconsin include dredging, sediment covering or consolidation, nutrient inactivation, hypolimnetic aeration, and total aeration. Other techniques, perhaps more properly classified as lake management practices, would include macrophyte harvesting or chemical control, algae chemical control, and fish management. The applicability of experimental techniques, such as biological control, selective discharge, algae harvesting, dilution/flushing, and inflow treatment, requires additional study. A brief description of lake rehabilitation techniques is set forth in Table 33.

In order to ascertain the need for lake rehabilitation techniques for a given lake and to obtain additional information required on the lake and its water quality, studies should be conducted to identify and characterize specific sites of shore erosion, upland erosion, septic tank system conditions, livestock sources, fertilization rates and amounts, and pet waste and debris accumulations; and to determine whether high nutrient concentrations and excessive aquatic plant growth continue after nutrients inputs are reduced. If water quality problems continue to occur, lake restoration and rehabilitation procedures should be implemented after determining:

1. the depth, composition, and nutrient release rate of the bottom sediments;

2. the types, location, and extent of algae, macrophytes, zooplankton, fish, and benthic organisms;

3. the chemical and physical characteristics and seasonal changes of the lake water quality;

4. the location, extent, flow rates, flow directions, and chemical characteristics of groundwater inflow and outflow; and

5. the in-lake flow patterns and other hydraulic phenomena affecting water quality.

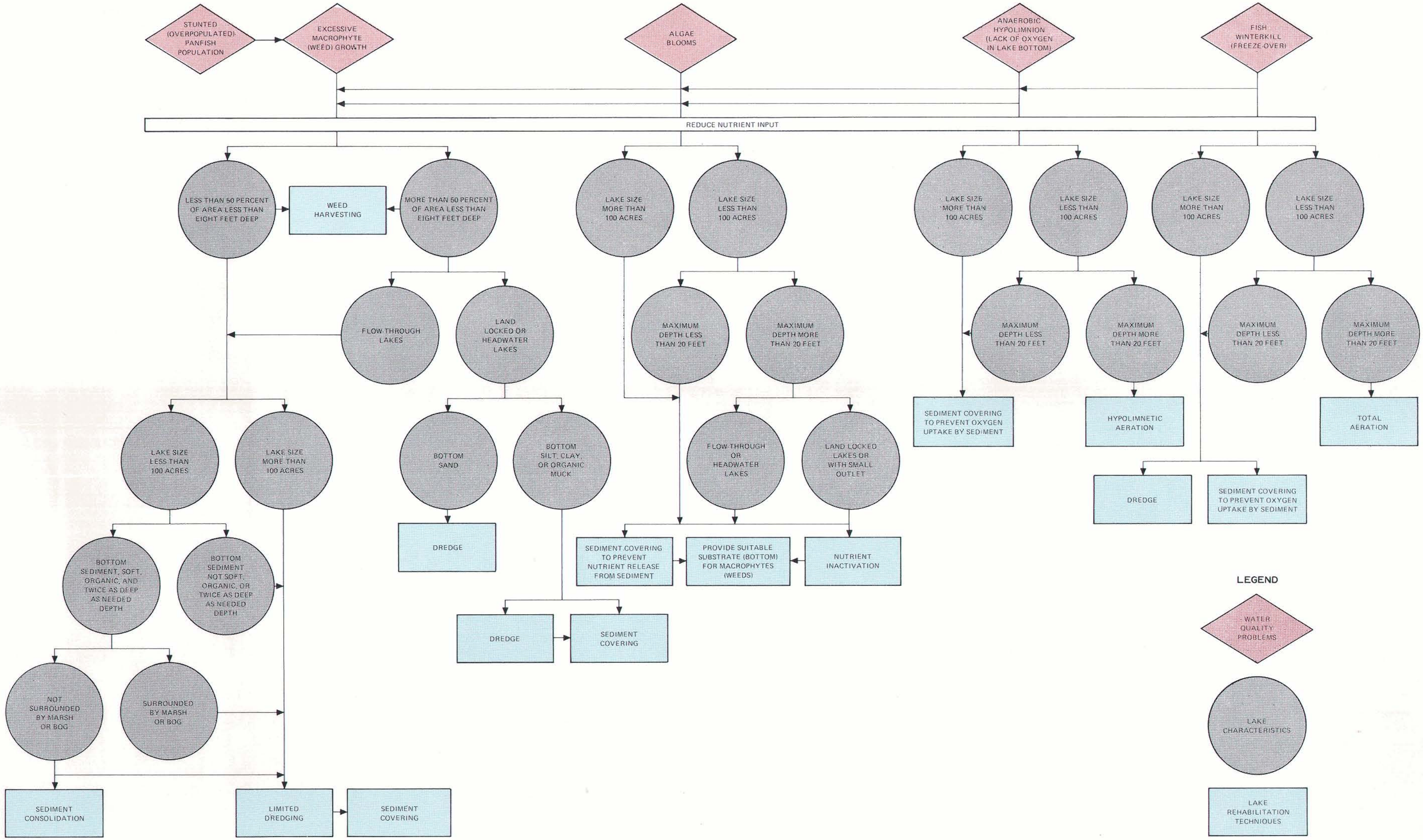
Once the physical, chemical, and biological characteristics of a lake are understood, local decisions can be made to implement the appropriate lake rehabilitation techniques to abate existing water quality problems which cannot be eliminated solely by reducing nutrient input.

Controlling Nutrient Inputs to Lakes

The same practices recommended to control diffuse source pollutant loads to streams, as shown in Tables 24 and 25, are recommended to control such loads to lakes as well. The individual practices to be applied in a given lake basin must be selected on the basis of detailed local lake district planning efforts, involving active public participation. Septic tank system manage-

Figure 16

**APPLICABILITY OF LAKE REHABILITATION TECHNIQUES IN SOUTHEASTERN WISCONSIN**




NOTE: This figure represents a general interpretation of the criteria used in selecting alternative lake rehabilitation techniques. Alternatives other than those noted above may be applicable as indicated by detailed field studies for any given lake or portions of any lake.

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Table 33

DESCRIPTION OF LAKE REHABILITATION TECHNIQUES APPLICABLE TO SOUTHEASTERN WISCONSIN

| Technique | Description and Effectiveness | Disadvantages |
|---|---|---|
| Dredging | Dredging is one of the most commonly used techniques and is effective in deepening lakes. A hydraulic dredge is often used. Benefits are an increased depth, possible induced lake stratification, and therefore reduced mixing of the sediments and water layers, removal of a suitable bottom substrata for macrophytes, improved navigation, and, if nutrient-poor sediments can be exposed, reduced nutrient release from sediments | Possible adverse environmental effects,[a] increased turbidity during operation, nutrient release from disturbed sediments, and high costs |
| Sediment Covering | Covering lake sediments may prevent release of nutrients and organic material from the sediments, prevent continued resuspension of the sediments, inhibit macrophyte growth by elimination of suitable bottom stabilization, and minimize water loss via infiltration. Several cover materials have been proposed, including sand, clay, plastic, rubber, fly ash, and gels | Unknown ecological and environmental impacts, possible return of macrophytes if an organic layer is deposited above the covering, possible algae problems if macrophytes are eliminated, and questionable long-term effectiveness |
| Sediment Consolidation | This technique involves lake drawdown and sediment drying. The dewatering reduces the volume of the sediments, which are highly organic, and increases the lake depth. The effects are irreversible; the sediments will not expand upon lake refilling | Sediment chemical changes may occur, increasing nutrient release to the water |
| Nutrient Inactivation | This promising technique has worked effectively for stratified lakes. The treatment may convert nutrients into a form unavailable for plant uptake, remove nutrients from the water column, and prevent release of nutrients from the sediments. The most commonly used material is alum (an aluminum compound), although iron compounds, ion exchange resins, fly ash, and clay have been proposed. Application may be on ice surfaces or under ice cover, or through water surface broadcast or subsurface manifold injection. This technique is effective in reducing algae problems | Limited applicability |
| Hypolimnetic (bottom) Aeration | The intent of this technique is to increase the dissolved oxygen content in the hypolimnion of stratified lakes without destroying the stratification. Typically, bottom water is lifted to the surface via a vertical tube and oxygenated water is returned to the hypolimnion. The decomposition of organic matter is increased and nutrient release is decreased. Available habitat for desirable fish species may be increased | The ecological effects of aeration need to be more thoroughly addressed. The practice is too expensive to be feasible in lakes larger than one or two hundred acres in size |
| Total Aeration | The prevention of fish winterkill and the destratification of lakes to provide oxygen to bottom layers are the primary intents of this technique. The general approach has been to circulate and thereby destratify lakes by pumping or injecting compressed air to the water bottom. The effect of destratification during winter is the maintenance of an open water area, which increases photosynthesis and oxygen diffusion from the air | The destratification effects eliminate cold water areas during summer required for some fish species |
| Macrophyte (weed) Harvesting | Harvesting macrophytes with mechanical harvesters increases the recreational use potential of lakes infested with excessive plant growth | The macrophytes must be harvested every year and disposal may be a problem. Some nutrients are removed from the lake but the amounts are usually minimal in terms of the total nutrient content of the lake |

Table 33 (continued)

| Technique | Description and Effectiveness | Disadvantages |
|---|---|---|
| Chemical Control | Excessive macrophyte growths, algae blooms, and undesirable fish populations may be controlled by chemical treatment. It is most applicable in highly eutrophic lakes where nutrient loads cannot be sufficiently reduced and where severe water use restrictions occur | Because of the potential adverse effects of adding poisonous chemicals to lakes, this technique requires cautious use in only the most extreme circumstances |
| Inflow Treatment | It is possible to treat inflowing surface runoff by many of the same procedures recommended for treatment of urban runoff. Additional encouraging treatment procedures have been proposed but few have been tested | Required high levels of sophisticated equipment and technical expertise and high costs have prevented the adequate demonstration of this technique |
| Dilution/Flushing | This technique involves the replacement of nutrient-rich lake water with nutrient-poor water from a stream or the groundwater. The method may be effective in reducing algae blooms | Long-term effects are questionable. Dilution/flushing is probably not applicable to most lakes in the Region, which are characteristically shallow and contain nutrient-rich sediments |
| Selective Discharge | Selective discharge involves the release of nutrient-rich, anaerobic water from the hypolimnion of a eutrophic lake. Nutrient levels are reduced and dissolved oxygen in the hypolimnion is increased | Further research on the overall effectiveness of this technique is needed, and it appears that the water quality of downstream reaches would be adversely affected |
| Biological Controls | This technique is a highly desirable approach and is inexpensive. Techniques are generally categorized into predator-prey relationships; species manipulation; and pathological reactions. Control organisms being evaluated include the white amur (grass carp), walleye, northern pike, snails, crayfish, waterfowl, insects, aquatic mammals, plant viruses, and fish parasites | This technique is still in the experimental stage and possible adverse environmental impacts could be substantial |

[a] *A discussion of the environmental effects of dredging activities is presented in SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin, Chapter V, "Diffuse Pollution Sources."*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

ment, livestock waste control, restricted fertilizer applications, and the prevention of pet waste accumulations and shoreland erosion are particularly important control measures for lakes. Furthermore, certain related problems, such as excessive rough fish populations, with the resulting reduction in water clarity, and poor shoreland management practices and beach litter may also be addressed during the local planning effort.

As part of the technical analyses, a determination had to be made of the approximate percent of the pollutant loadings that reached a major inland lake as a result of manure produced by livestock in a direct drainage area to the lake. A literature search revealed very limited published research information on this matter. The conclusions of this literature search are recorded in SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, Chapter V, "Diffuse Sources of Water Pollution in the Region." One of the conclusions reached was that about 20 percent of the pollutant loading from such manure eventually reached the lake. Subsequent to the completion of the water quality planning work, the International Joint Commission studies on pollution from land use activities contributed research results that indicated that manure loadings to local waterways range from 5 to 10 percent of the total livestock waste generated. This conclusion is published in D. W. Draper, J. B. Robinson, D. R. Coote, "Estimation and management of the contribution by manure by livestock in the Ontario Great Lakes Basin to the phosphorus loading of the Great Lakes," published in Proceedings of the 1978 Cornell Conference on Best Management Practices for Agriculture and Silviculture, Rochester, New York, 1978. Since livestock waste control was considered a basic minimum practice and incorporated in the plan recommendation for the entire Region, this recent research finding does not significantly affect plan recommendations or costs for inland lake management. Moreover, a check of the accuracy of the estimated inlake phosphorus concentrations against selected measured values available indicated that the analytic results were reasonable.

Concluding Remarks—Lake Water Quality Analytic Procedures

This section has discussed the analytical techniques used in the areawide water quality management planning program to develop initial proposals aimed at the preservation or enhancement of lake water quality in the Region. The long-term maintenance or enhancement of lake water quality will require substantial technical expertise and monetary expenditures, along with the realization by citizens and local and state planning agencies that the effectiveness of the practices and the absolute avoidance of adverse environment impacts cannot be guaranteed, given the current state-of-the-art. Proper technical support and monitoring programs, however, together with additional research and development, should maximize the chance of successful lake management and minimize adverse environmental impacts.

## DIFFUSE SOURCE WATER POLLUTION CONTROL MEASURES FOR STREAMS

The inventory and analysis phases of the water quality management planning program presented in Volume One of this report identified and characterized water pollution problems in the Region. This section presents water quality management measures intended to resolve stream water pollution caused by diffuse sources of pollution. Water quality conditions are discussed for the flowing streams of the Region, as are the recommended management practices and control measures and the attendant costs. The following discussion presents the results of the water quality analyses for existing and probable future conditions, and presents diffuse source management practices, along with the associated costs. Lake water quality analyses and the design and cost of diffuse source pollution abatement measures for the direct drainage areas of the 100 major lakes in the Region are addressed in Appendix C.

The existing land use conditions and associated diffuse sources of pollution in southeastern Wisconsin are discussed for each watershed in Volume One, Chapter V of this report. Hourly streamflow and water quality conditions for each watershed were simulated under existing land use and channel conditions for a representative three-year period using the hydrologic-hydraulic water quality simulation model, and the results were statistically analyzed for 169 stream locations within the Region. The areas immediately tributary to the stream simulation model output locations are hereafter referred to as water quality analysis areas. The water quality of all major streams and their major tributaries was also simulated under the year 2000 planned land use conditions, as graphically summarized on Map 2 in this chapter.

### Existing and Forecast Water Quality Conditions and Required Pollution Controls

The simulation of existing water quality conditions served as a baseline for the year 2000 simulations with and without various levels of diffuse source pollutant loading reductions and provided for the calibration of a model using water quality sampling data obtained in 1976 and 1977 by the Commission. The following discussion presents the percent of time the applicable water quality standards are satisfied under existing land use conditions as well as under year 2000 planned land use conditions with only the point source controls, as recommended in a later section of this chapter, and with point source controls coupled with various reductions in diffuse source pollutant loadings, thereby identifying the level of pollution control required within the various water quality analysis areas of each watershed to meet the applicable water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus. Also presented for each watershed are the estimated diffuse source control costs and a discussion of the areas of differing pollution potential within each watershed.

### Des Plaines River Watershed

The water quality of the Des Plaines River and its major tributaries was simulated for 88 stream reaches and the associated subbasins, with the results reported and statistically analyzed for 10 simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The locations of these 10 simulation sites and the corresponding tributary water quality analysis areas are shown on Map 5 and presented in Table 34. The following discussion and Figures 17 through 26 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions with point source controls only, and with point source controls coupled with a 50 percent reduction in diffuse source pollutant loadings. All streams in the Des Plaines River watershed are classified for warmwater fishery and aquatic life, recreational use, and minimum standards.

Table 34

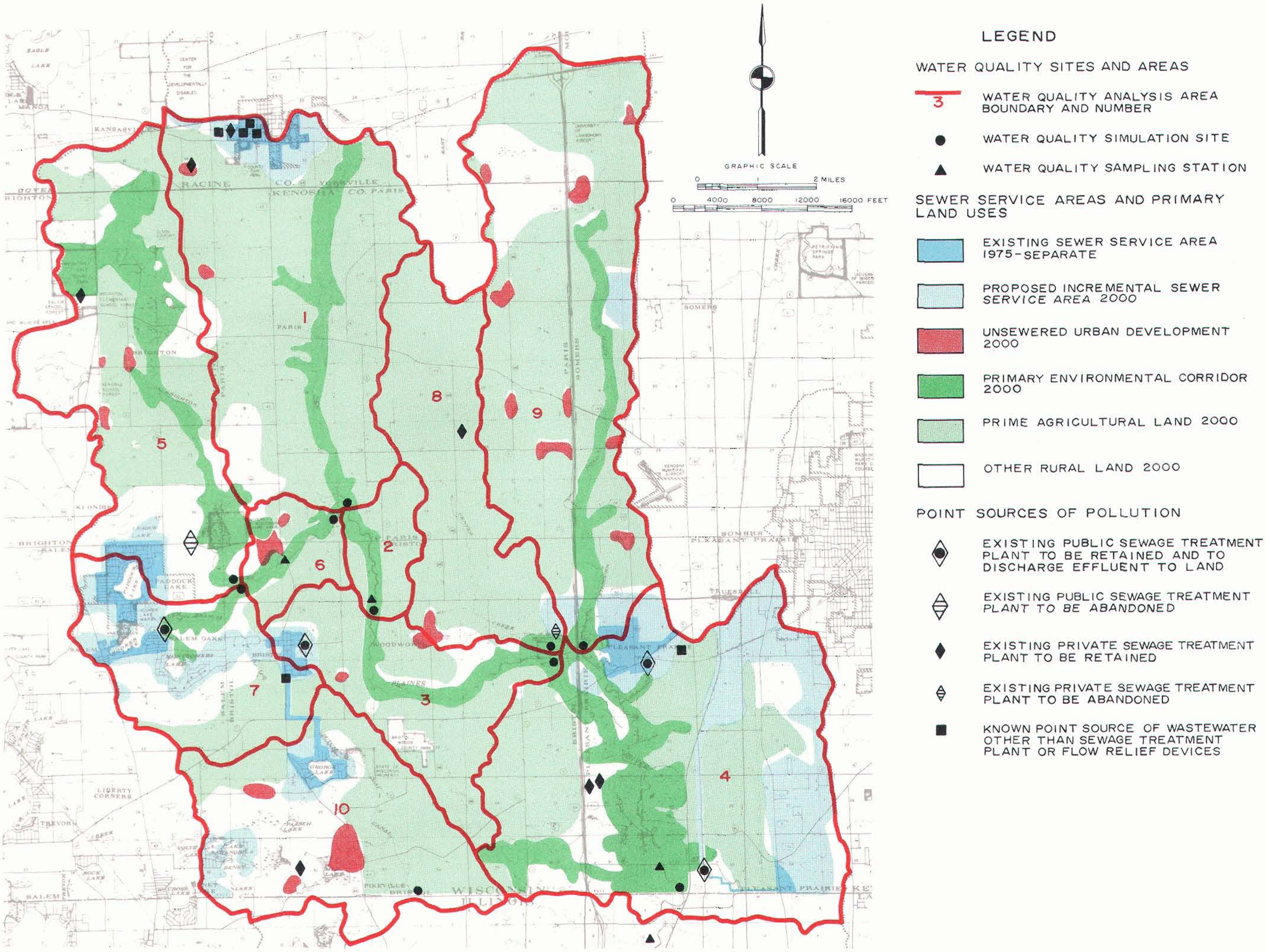
LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE DES PLAINES RIVER WATERSHED

| Water Quality Analysis Areas as Presented on Map 5 | Location of Most Downstream Point Draining the Water Quality Analysis Area: Location | U. S. Public Land Survey Designation |
|---|---|---|
| | Des Plaines River | |
| 1 | Upstream of the confluence with Brighton Creek | T2N, R21E, Section 33 |
| 2 | At STH 50 | T1N, R21E, Section 9 |
| 3 | Upstream of the confluence with Center Creek | T1N, R21E, Section 12 |
| 4 | At the Wisconsin-Illinois border | T1N, R22E, Section 32 |
| | Brighton Creek | |
| 5 | Upstream of the confluence with Salem Branch | T1N, R21E, Section 6 |
| 6 | At the confluence with the Des Plaines River main stem | T2N, R21E, Section 33 |
| | Salem Branch of Brighton Creek | |
| 7 | At the confluence with Brighton Creek | T1N, R21E, Section 6 |
| | Center Creek | |
| 8 | At the confluence with the Des Plaines River main stem | T1N, R21E, Section 12 |
| | Kilbourn Road Ditch | |
| 9 | At the confluence with the Des Plaines River | T1N, R22E, Section 7 |
| | Dutch Gap Canal | |
| 10 | At the Wisconsin-Illinois state line | T1N, R21E, Section 34 |

*Source: SEWRPC.*

Map 5

WATER QUALITY ANALYSIS AREAS IN THE DES PLAINES RIVER WATERSHED




The Des Plaines River watershed has an area of 132 square miles and ranks sixth in size and tenth in total resident population of the 12 watersheds in the Region. Within the Des Plaines River watershed there are 88 identified hydrologic subbasins grouped into 10 water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are four sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 22 point sources of water pollution—including three sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo a moderate level of urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 9 and 14 percent of the total watershed area, respectively.

*Source: SEWRPC.*

Temperature: It is apparent from Figures 17 through 26 that the temperature standard of 89°F is satisfied within the Des Plaines River watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: In general, only minimum diffuse source controls will be necessary to satisfy the warmwater fishery and aquatic life dissolved oxygen standard of 5 milligrams per liter (mg/l) within the Des Plaines River watershed. However, severe dissolved oxygen problems are indicated in all analysis areas except areas 5 and 7, which are drained by Brighton Creek and the Salem Branch, respectively. These problems are caused by high oxygen demand from bottom deposits and benthic organisms, and are estimated to be primarily attributable to historical and existing contributions from both point and diffuse sources. Upon the control of these point sources and the implementation of minimum diffuse source controls under plan year 2000 conditions, it is likely that these bottom deposits will either stabilize or be assimilated by the stream system. If, following the implementation of pollution control measures, the benthic oxygen demand is not sufficiently reduced, the possibility of channel dredging activities should be investigated to facilitate the stabilization of some severe areas. A 50 percent reduction in the oxygen demand from the bottom deposits will achieve the desired level of dissolved oxygen.

Figures 17-24

# EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE DES PLAINES RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 17

WATER QUALITY ANALYSIS AREA 1

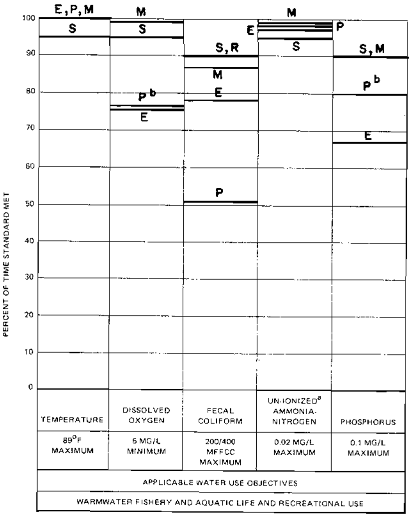



Figure 18

WATER QUALITY ANALYSIS AREA 2

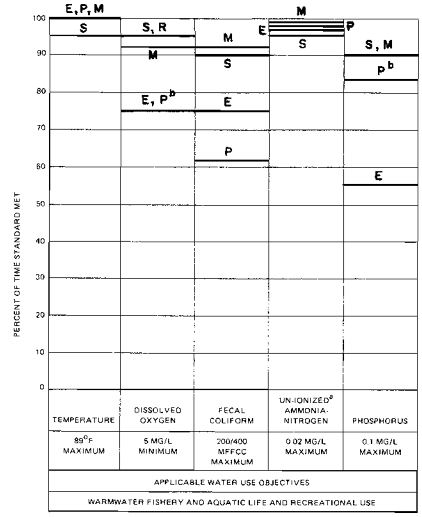


Figure 19

WATER QUALITY ANALYSIS AREA 3

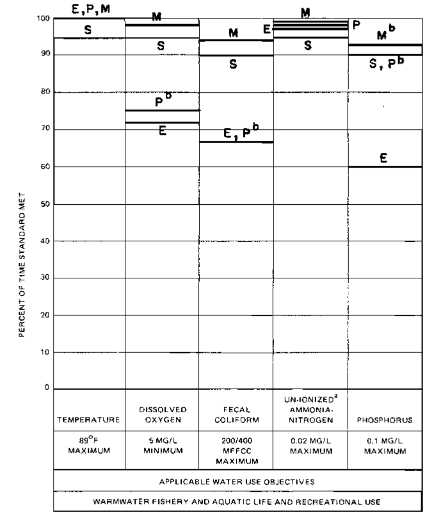


Figure 20

WATER QUALITY ANALYSIS AREA 4

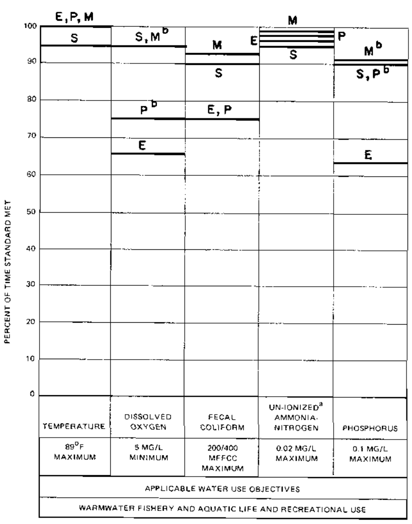


Figure 21

WATER QUALITY ANALYSIS AREA 5

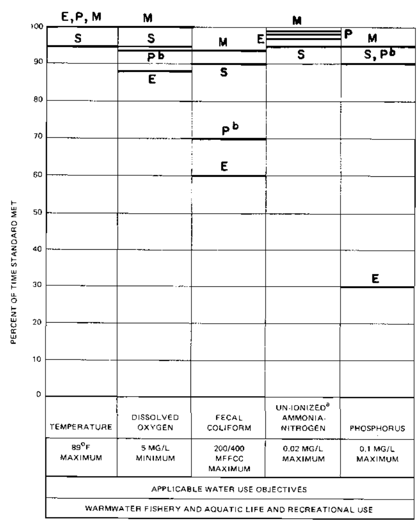


Figure 22

WATER QUALITY ANALYSIS AREA 6

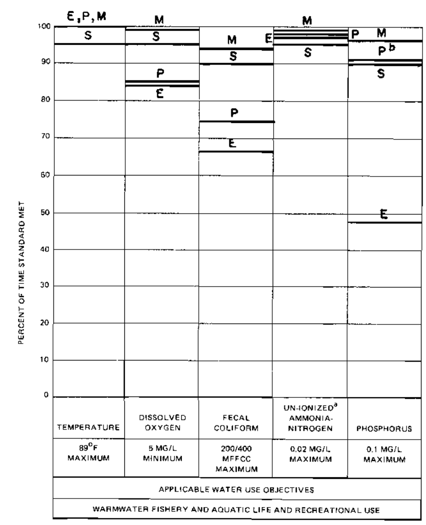


Figure 23

WATER QUALITY ANALYSIS AREA 7

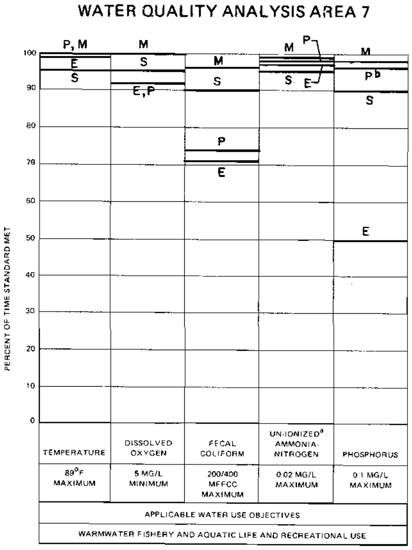
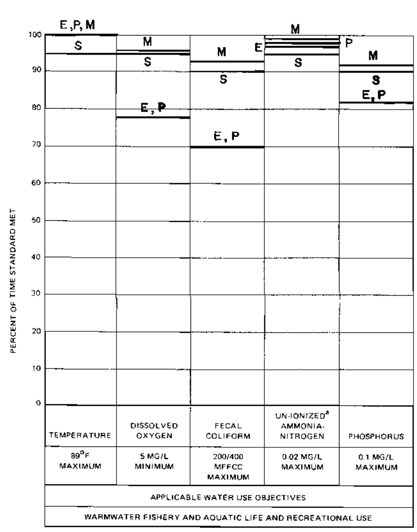


Figure 24

WATER QUALITY ANALYSIS AREA 8



LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

*Source: SEWRPC.*

## Figures 25-26

### EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE DES PLAINES RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 25

WATER QUALITY ANALYSIS AREA 9

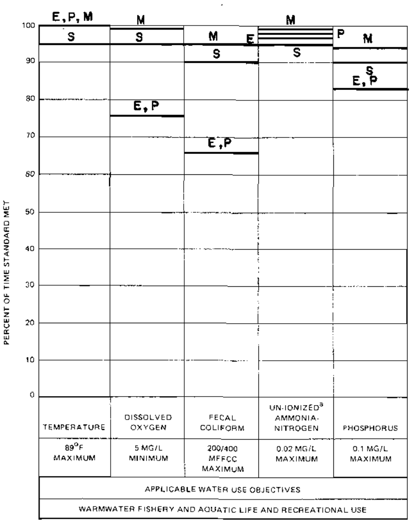
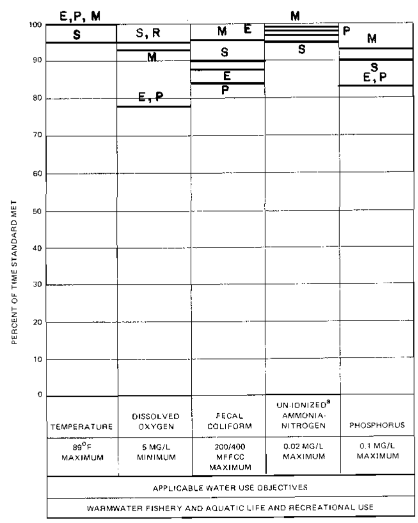



Figure 26

WATER QUALITY ANALYSIS AREA 10




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

*Source: SEWRPC.*

Fecal Coliform: All water quality analysis areas within the Des Plaines River watershed may be expected to satisfy a fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml) under a diffuse source pollutant loading reduction of 50 percent.

Phosphate-Phosphorus: Water quality analysis areas 1, 2, 8, 9, and 10 will require a 50 percent level of diffuse source control to satisfy the phosphorus standard of 0.1 mg/l at least 90 percent of the time. Analysis areas 3 through 7 are expected to satisfy the standard at least 90 percent of the time without diffuse source controls assuming the recommended point source controls are implemented.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Des Plaines River watershed indicate that the standard of 0.02 mg/l should seldom be exceeded. Diffuse source controls should not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Summary: Table 35 presents the general level of diffuse source pollutant loading reductions and bottom oxygen demand reductions necessary to satisfy the applicable water quality standards for the Des Plaines River watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Des Plaines River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 6 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 36 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

The pollution potential classification analysis for the Des Plaines River watershed indicated relatively little variation in urban pollution potential, with more than

### Table 35

### REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE DES PLAINES RIVER WATERSHED

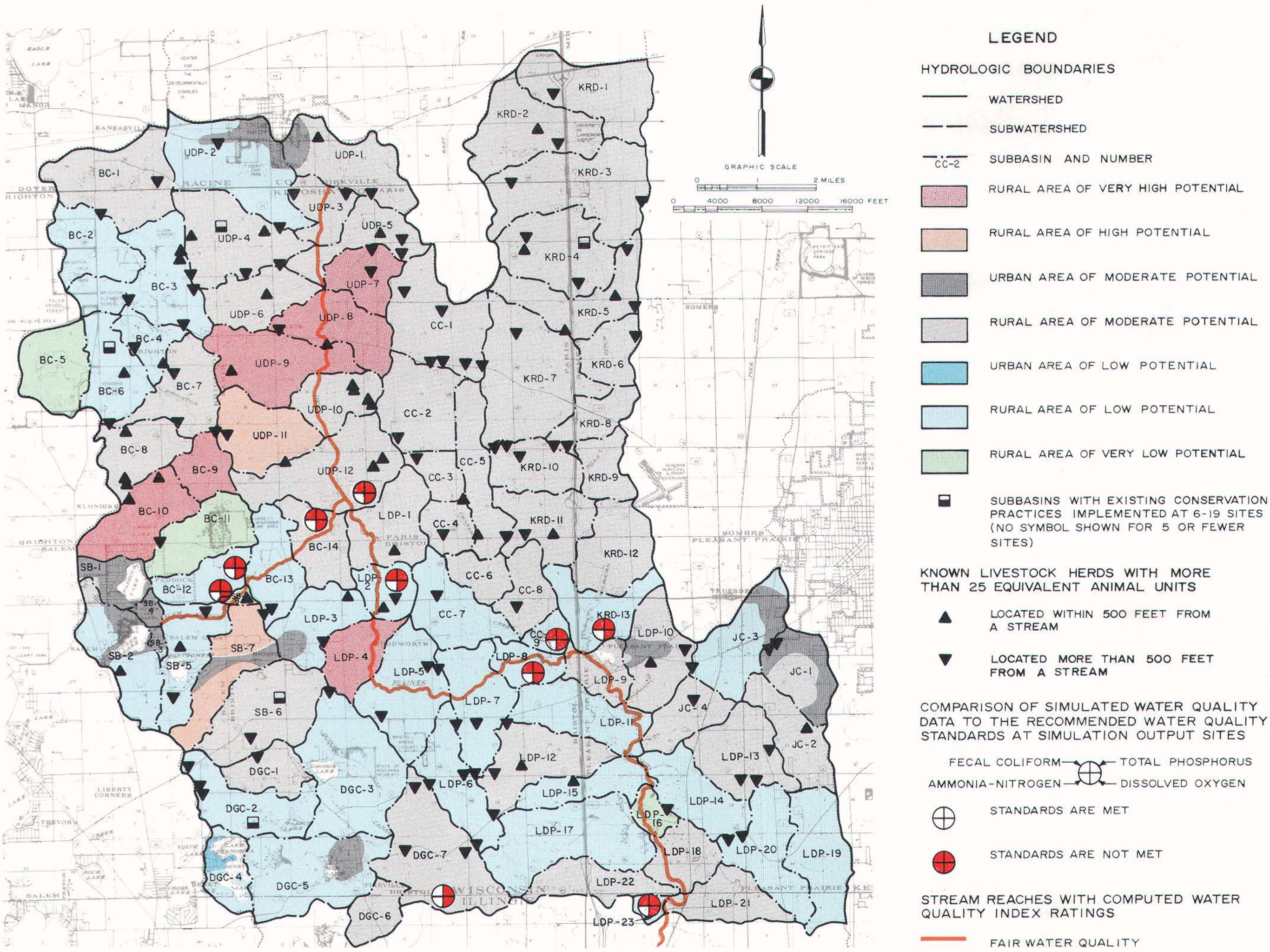
| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum[a] | 50 | Minimum | 50 |
| 2 | Minimum[a] | 50 | Minimum | 50 |
| 3 | Minimum[a] | 50 | Minimum | Minimum |
| 4 | Minimum[a] | 50 | Minimum | Minimum |
| 5 | Minimum | 50 | Minimum | Minimum |
| 6 | Minimum[a] | 50 | Minimum | Minimum |
| 7 | Minimum | 50 | Minimum | Minimum |
| 8 | Minimum[a] | 50 | Minimum | 50 |
| 9 | Minimum[a] | 50 | Minimum | 50 |
| 10 | Minimum[a] | 50 | Minimum | 50 |

[a] *Requires reduction in benthic oxygen demand, which is expected to result if point source controls and minimum diffuse source controls are implemented.*

*Source: SEWRPC.*

Map 6

DIFFUSE SOURCE POLLUTION POTENTIAL IN THE DES PLAINES RIVER WATERSHED: 1975




The hydrologic subbasins in the Des Plaines River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 2,317 acres devoted to urban land uses in the watershed, more than 90 percent recorded a moderate potential rating for nonpoint source pollution. Of the 82,310 acres devoted to rural land uses in the watershed, 9 percent was estimated to have a high or very high pollution potential, 51 percent a moderate potential, and the remaining 40 percent a low or very low potential for nonpoint source pollution. Thus, as of 1975, the Des Plaines River watershed exhibited a moderate potential for urban nonpoint source pollution and a variable but generally moderate potential for rural nonpoint source pollution.

*Source: SEWRPC.*

90 percent of the analyzed urban areas receiving a moderate rating. Less than 10 percent of the rural area is designated by a high or very high pollution potential rating, with more than 85 percent of the area being classified as having low or moderate potential. The largest area of high rural pollution potential covers U. S. Public Land Survey Sections 9, 16, 17, 18, and 19 in the Town of Paris in Kenosha County. In general, the southern half of the watershed has a lower rural pollution potential rating than does the northern half.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Des Plaines River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to

Table 36

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE DES PLAINES RIVER WATERSHED:[a] 1975

| Pollution Potential Classification | Urban Areas[b] Area (acres) | Urban Areas[b] Percent of Total Urban Area | Rural Areas[b] Area (acres) | Rural Areas[b] Percent of Total Rural Area | Total Watershed Area (acres) | Total Watershed Percent of Total Watershed Area |
|---|---|---|---|---|---|---|
| Very High . . | -- | -- | 5,762 | 7 | 5,762 | 7 |
| High . . . . . | -- | -- | 1,646 | 2 | 1,646 | 2 |
| Moderate. . . | 2,155 | 93 | 41,978 | 51 | 44,133 | 52 |
| Low. . . . . . | 162 | 7 | 29,632 | 36 | 29,794 | 35 |
| Very Low . . | -- | -- | 3,292 | 4 | 3,292 | 4 |
| Total | 2,317 | 100 | 82,310 | 100 | 84,627 | 100 |

[a] *Includes areas tributary to the four major lakes in the watershed.*

[b] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

protect the water quality of the Des Plaines River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding ponds, are needed to sufficiently reduce pollutant loadings from all animal operations. In addition, those animal operations located less than 500 feet from a stream and in very high or high pollution potential areas (see Map 6) may require storage through the winter in a dry stacking system incorporating runoff control or a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff. The control of livestock waste runoff is expected to sufficiently alleviate fecal coliform and phosphorus problems in the watershed.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $4.0 million, of which $2.8 million, or 70 percent, would be for urban practices and $1.2 million, or 30 percent, would be for rural practices, and an average annual operation and maintenance cost of $228,000, of which $30,000, or 13 percent, would be for urban practices and $198,000, or 87 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 37.

Table 37

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE DES PLAINES RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] . . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . . . . . . . . . . . . | Minimal | 12,000 |
| Industrial and Commercial Material Storage Facilities Runoff Control Measures . . . . . . . . | 159,000 | Minimal |
| Construction Erosion Control Practices. . . . . . . . . . . . . | 2,639,000 | 18,000 |
| Subtotal | $2,798,000 | $ 30,000 |
| Rural | | |
| Minimum Conservation Practices[c]. . . . | 20,000 | 122,000 |
| Livestock Waste Control . . . . . . . . . | 1,197,000 | 76,000 |
| Subtotal | $1,217,000 | $198,000 |
| Total | $4,015,000 | $228,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Des Plaines River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $2,815,000, and an average annual operation and maintenance cost of $91,000.*

[b] *Low-cost urban controls include pet waste and litter control, fertilizer and pesticide use restrictions, public education programs, improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning, and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

## Fox River Watershed

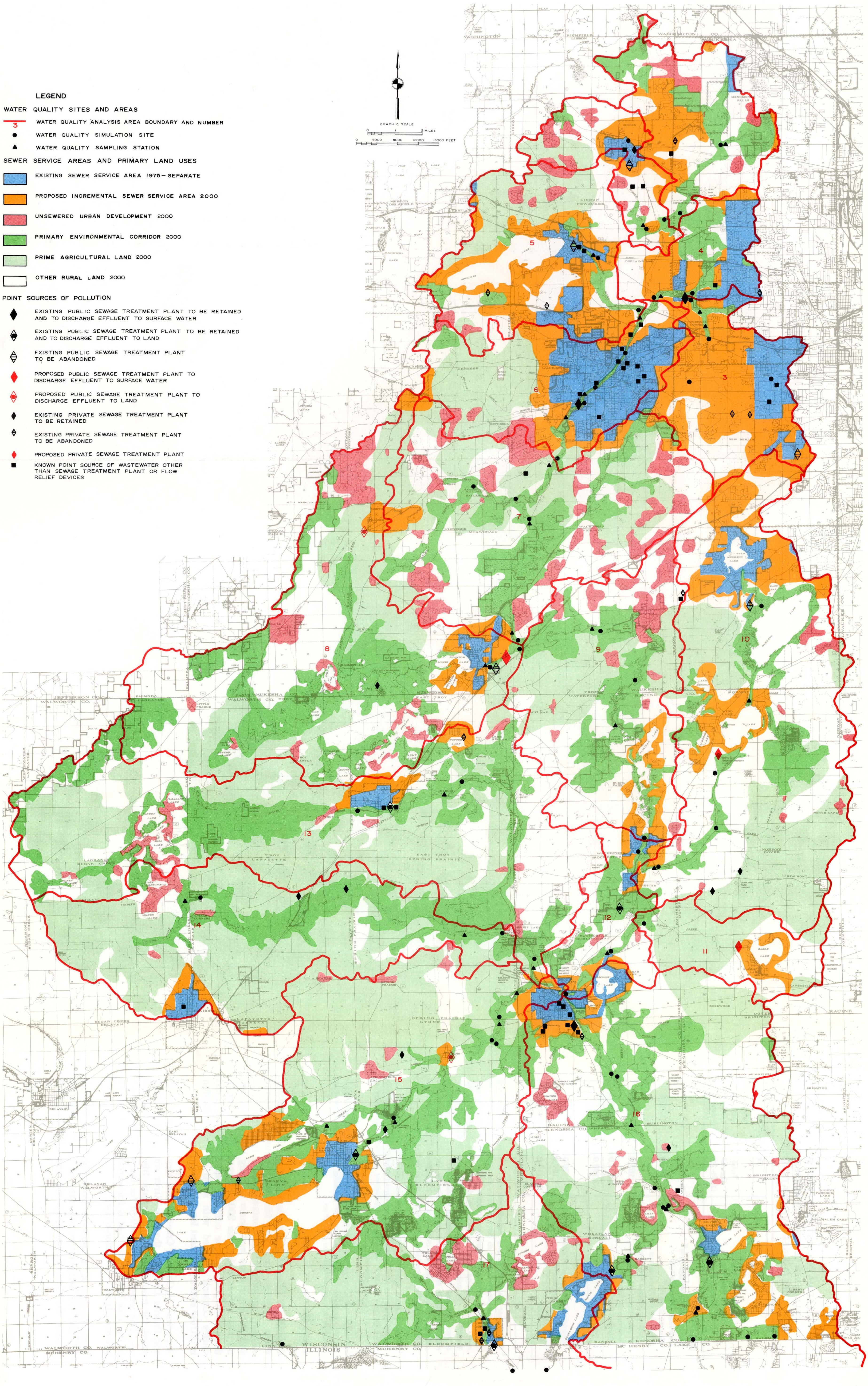
The water quality of the Fox River and its major tributaries was simulated for 578 stream reaches and their associated subbasins, with the results reported and statistically analyzed for 57 stream simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. To facilitate the presentation of the analyses in this section, the areas tributary to the simulation sites were aggregated into 17 water quality analysis areas, and data are presented herein only for the corresponding most downstream simulation site within each area. The locations of the simulation sites and the corresponding 17 water quality analysis areas are shown on Map 7 and presented in Table 38. The following discussion and Figures 27 through 43 present the percent of time the applicable water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions with point source controls only, and with point source controls coupled with a 50 percent reduction in diffuse source pollutant loadings.

A portion of Genesee Creek, a tributary of Sugar Creek, and Palmer Creek in the Fox River watershed are classified for trout fishery and aquatic life and recreational use. The water use designation for the remaining streams in the Fox River watershed is for warmwater fishery and aquatic life and recreational use.

Temperature: It is apparent from Figures 27 through 43 that the temperature standard of 89°F is satisfied within the Fox River watershed and that pollutant

Map 7

## WATER QUALITY ANALYSIS AREAS IN THE FOX RIVER WATERSHED




The Fox River watershed has an area of 948 square miles and is the largest in size and the fifth largest in total resident population of the 12 watersheds in the Region. Within the Fox River watershed there are 578 identified hydrologic subbasins grouped into 17 water quality analysis areas, with 57 stream water quality simulation output sites. Also located within the watershed are 32 sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 95 point sources of water pollution—including 20 sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo a moderate level of urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 14 and 18 percent of the total watershed area, respectively.

*Source: SEWRPC.*

Figures 27-43

# EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE FOX RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 27

WATER QUALITY ANALYSIS AREA 1

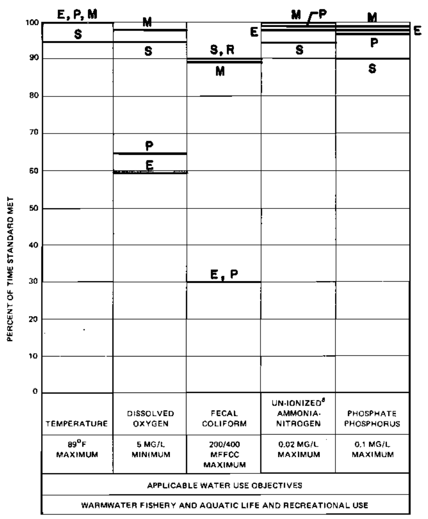



Figure 28

WATER QUALITY ANALYSIS AREA 2

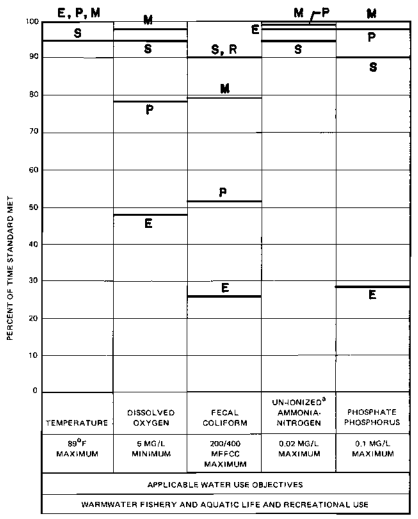


Figure 29

WATER QUALITY ANALYSIS AREA 3

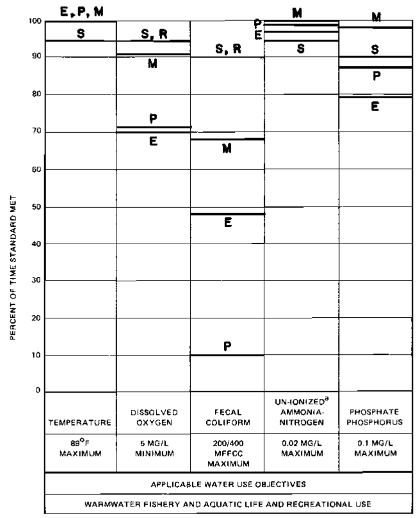


Figure 30

WATER QUALITY ANALYSIS AREA 4

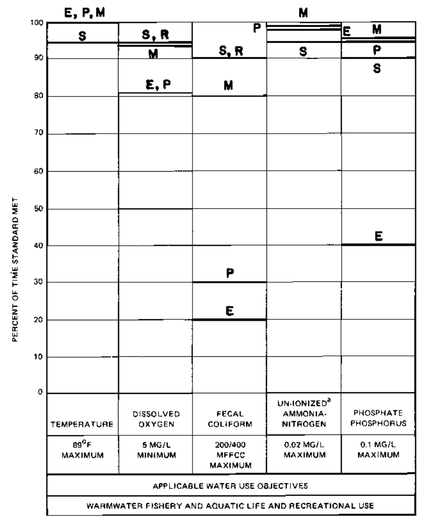


Figure 31

WATER QUALITY ANALYSIS AREA 5

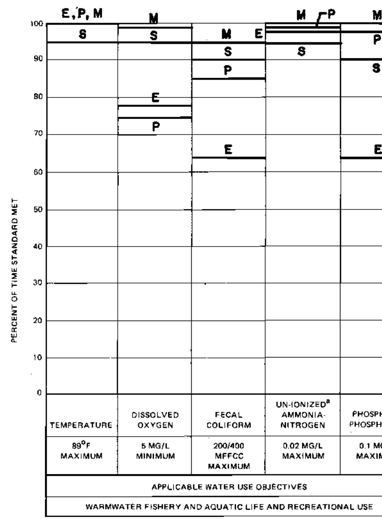


Figure 32

WATER QUALITY ANALYSIS AREA 6

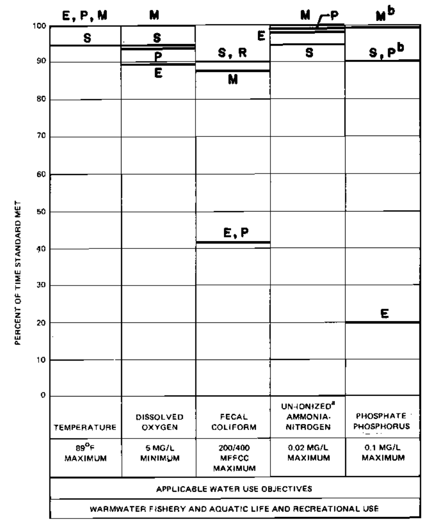


Figure 33

WATER QUALITY ANALYSIS AREA 7

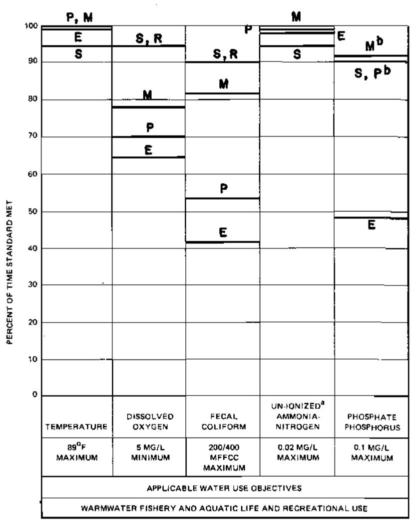


Figure 34

WATER QUALITY ANALYSIS AREA 8

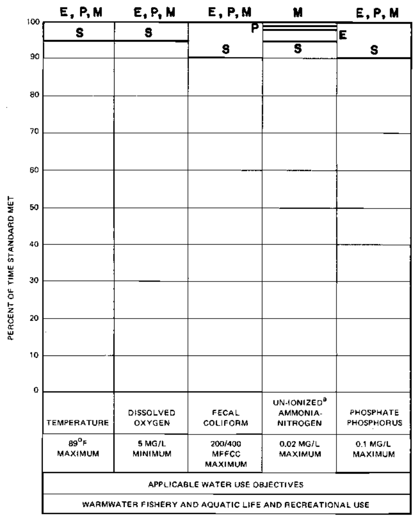


Figure 35

WATER QUALITY ANALYSIS AREA 9

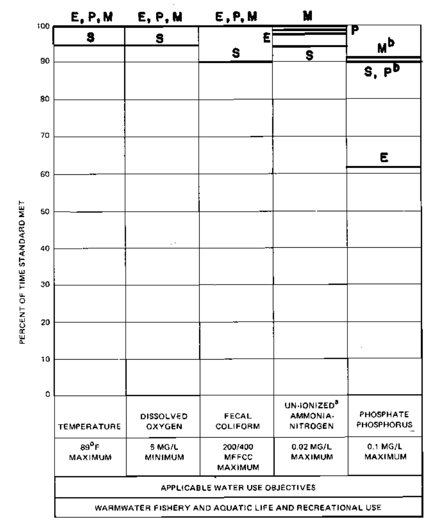


Figure 36

WATER QUALITY ANALYSIS AREA 10

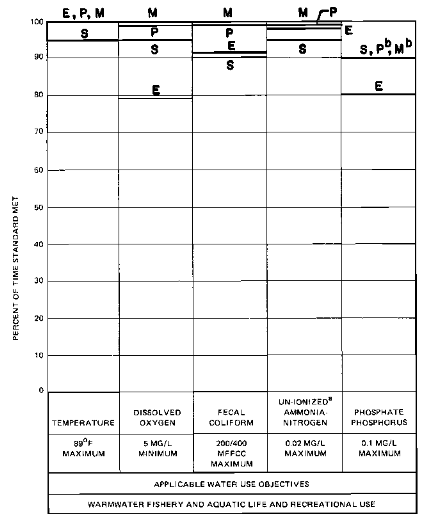


Figure 37

WATER QUALITY ANALYSIS AREA 11

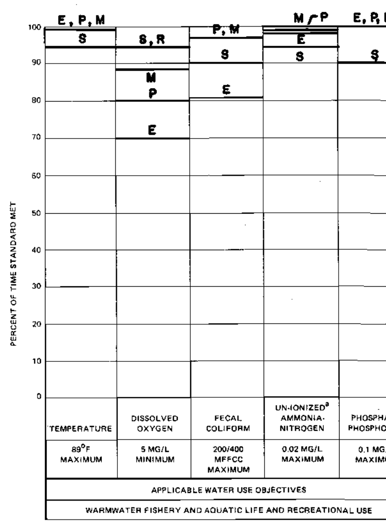


Figure 38

WATER QUALITY ANALYSIS AREA 12

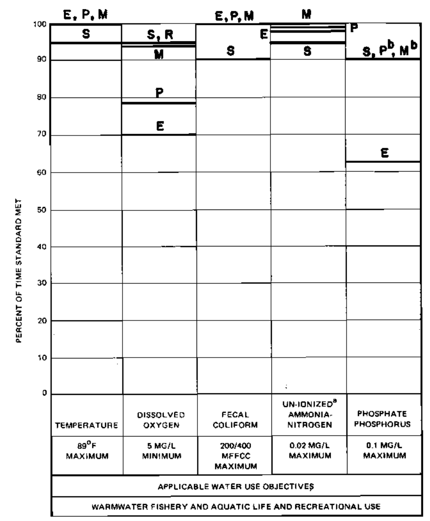


Figure 39

WATER QUALITY ANALYSIS AREA 13

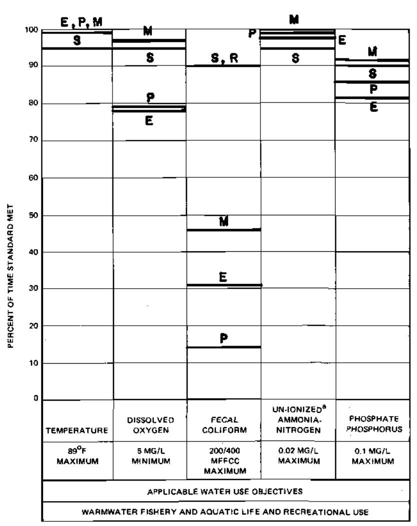


Figure 40

WATER QUALITY ANALYSIS AREA 14

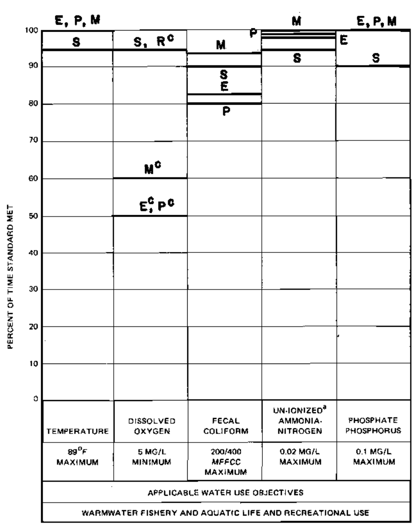


Figure 41

WATER QUALITY ANALYSIS AREA 15

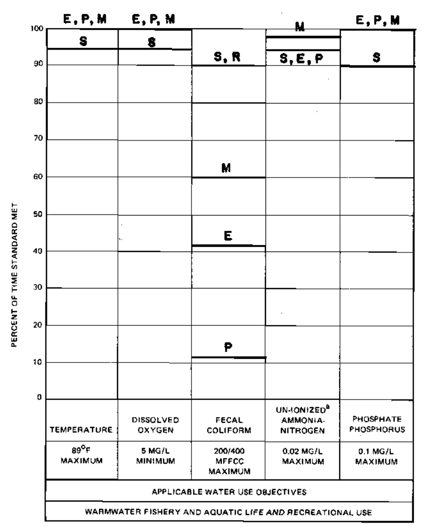


Figure 42

WATER QUALITY ANALYSIS AREA 16

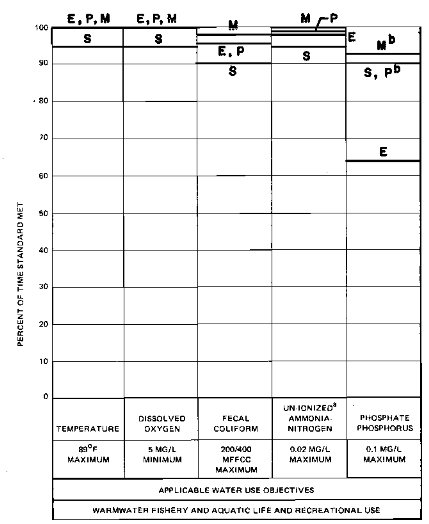
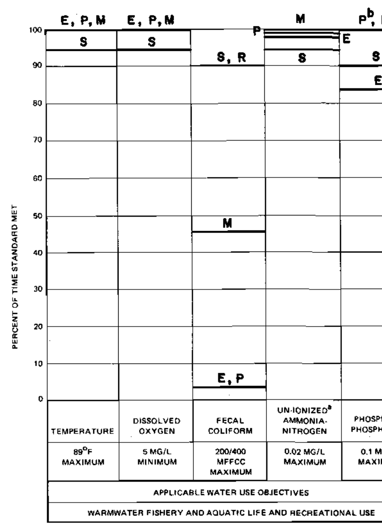


Figure 43

WATER QUALITY ANALYSIS AREA 17



LEGEND

**S** — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

**E** — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

**P** — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**M** — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**R** — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

[c] *THE VALUES REFLECT THE EFFECTS OF CALIBRATING DISSOLVED OXYGEN SIMULATIONS WITH DATA OBTAINED IN AUTUMN, WHEN BENTHIC OXYGEN DEMAND WAS RELATIVELY LESS IMPORTANT THAN DURING THE SIMULATION OF CERTAIN OTHER CONDITIONS DURING THE CONTINUOUS 3-YEAR SIMULATION PERIOD. HIGHER TEMPERATURES DURING OTHER PARTS OF THE YEAR INCREASE THE SIMULATED BIOLOGICAL ACTIVITY OF THE BENTHOS TO LEVELS WHICH REDUCE THE DISSOLVED OXYGEN BELOW LEVELS TYPICAL OF SUGAR CREEK. ACCORDINGLY, BASED ON ACTUAL STREAM SAMPLES OBTAINED IN THE COMMISSION CONTINUING WATER QUALITY SAMPLING PROGRAM SINCE 1964, AND BASED ON ANALYSES OF SIMULATION CURVES FROM DRAINAGE AREAS SIMILAR TO SUGAR CREEK, IT WAS ESTIMATED THAT THE CONTROL OF BOTH POINT AND NONPOINT POLLUTION SOURCES COULD ACHIEVE THE WATER QUALITY STANDARDS.*

*Source: SEWRPC.*

## Table 38

## LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE FOX RIVER WATERSHED

| Water Quality Analysis Areas as Presented on Map 7 | Location of Most Downstream Point Draining the Water Quality Analysis Area | |
|---|---|---|
| | Location | U. S. Public Land Survey Designation |
| 1 | Fox River<br>Town of Brookfield, north of Capitol Drive, west of Barker Road | T7N, R20E, Section 6 |
| 2 | Sussex Creek<br>Town of Pewaukee, at confluence of Sussex Creek with the Fox River | T7N, R19E, Section 1 |
| 3 | Poplar Creek<br>Town of Brookfield, at confluence of Poplar Creek with the Fox River | T7N, R19E, Section 19 |
| 4 | Fox River<br>Town of Pewaukee, CTH SS east of CTH M | T7N, R19E, Section 24 |
| 5 | Pewaukee River<br>Town of Pewaukee, south of IH 94 | T7N, R19E, Section 25 |
| 6 | Fox River<br>City of Waukesha, east of CTH HI, north of CTH I | T6N, R19E, Section 16 |
| 7 | Fox River<br>Town of Mukwonago, south of CTH ES upstream of Mukwonago River | T5N, R18E, Section 30 |
| 8 | Mukwonago River<br>Town of Mukwonago, north of STH 15 | T5N, R19E, Section 30 |
| 9 | Fox River<br>Village of Waterford, north of STH 83, west of STH 20 | T4N, R19E, Section 35 |
| 10 | Wind Lake Drainage Canal<br>Town of Rochester, west of STH 20 | T3N, R19E, Section 1 |
| 11 | Eagle Creek<br>Town of Rochester, east of STH 83, north of CTH A | T3N, R19E, Section 14 |
| 12 | Fox River<br>City of Burlington, west of CTH W, north of STH 11 | T3N, R19E, Section 32 |
| 13 | Honey Creek<br>Town of Burlington, west of the Soo Line right-of-way | T3N, R19E, Section 19 |
| 14 | Sugar Creek<br>Town of Spring Prairie, west of CTH DD | T3N, R18E, Section 13 |
| 15 | White River<br>Town of Spring Prairie, north of STH 36 | T3N, R18E, Section 36 |
| 16 | Fox River<br>Town of Salem, at state line west of CTH B | T1N, R20E, Section 31 |
| 17 | Nippersink Creek<br>Village of Genoa City, at the state line | T1N, R18E, Section 35 |

*Source: SEWRPC.*

loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: In general, only minimum diffuse source controls will be necessary to satisfy the warmwater fishery and aquatic life dissolved oxygen standard of 5 milligrams per liter (mg/l) within the Fox River watershed. However, severe dissolved oxygen problems are indicated in water quality analysis areas 1, 2, 3, 4, 5, 7, 11, 12, 13, and 14. These problems are caused by high oxygen demand from bottom deposits and benthic organisms, and are estimated to be primarily attributable to historical and existing contributions from both point and diffuse sources. Upon the control of these point sources and the implementation of minimum diffuse source controls under plan year 2000 conditions, it is likely that these bottom deposits will either stabilize or be assimilated by the stream system. If following the implementation of pollution control measures, the benthic oxygen demand is not sufficiently reduced, the possibility of channel dredging activities should be investigated to facilitate the stabilization of some severe areas. A 50 percent reduction in the benthic oxygen demand will usually achieve the desired level of dissolved oxygen in the stream.

Fecal Coliform: The fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml) is satisfied for water quality analysis areas 8 through 12 and 16 under year 2000 land use conditions with no reductions in diffuse source pollutant loadings. An estimated 50 percent reduction in diffuse source fecal coliform loads is indicated for analysis areas 1, 5, and 14. Seventy-five percent of the diffuse source fecal coliform loads will need to be controlled before the applicable standard can be satisfied in analysis areas 2, 3, 4, 6, 7, 13, 15, and 17.

Phosphate-Phosphorus: Under year 2000 land use conditions with recommended point source controls, most of the Fox River watershed is not anticipated to require diffuse source controls to satisfy the applicable recreational use phosphorus standard of 0.1 mg/l. However, some urban areas within analysis area 3, which is drained by Poplar Creek and Deer Creek, and area 13, which is drained by Honey Creek, will require a 50 percent reduction in diffuse source phosphate loadings to satisfy the applicable standard. The violations in area 3 are attributed to urban land runoff and malfunctioning septic systems. Rural land and livestock waste runoff is the primary phosphorus source in area 13.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Fox River watershed indicate that the level of 0.02 mg/l should seldom be exceeded. Diffuse source controls should not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Summary: Table 39 presents the general level of diffuse source pollutant loading reductions necessary to satisfy the applicable water quality standards for the Fox River watershed. Required reduction levels are presented for phosphate-phosphorus, dissolved oxygen, un-ionized ammonia-nitrogen, and fecal coliform. Diffuse source controls are needed to meet the fecal coliform standard throughout most of the watershed and the phosphorus standard in a few areas.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Fox River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 8 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 40 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

Table 39

REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREA IN THE FOX RIVER WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum[a] | 50 | Minimum | Minimum |
| 2 | Minimum[a] | More than 50 | Minimum | Minimum |
| 3 | Minimum[a] | More than 50 | Minimum | 50 |
| 4 | Minimum[a] | More than 50 | Minimum | Minimum |
| 5 | Minimum[a] | 50 | Minimum | Minimum |
| 6 | Minimum | More than 50 | Minimum | Minimum |
| 7 | Minimum[a] | More than 50 | Minimum | Minimum |
| 8 | Minimum | Minimum | Minimum | Minimum |
| 9 | Minimum | Minimum | Minimum | Minimum |
| 10 | Minimum | Minimum | Minimum | Minimum |
| 11 | Minimum[a] | Minimum | Minimum | Minimum |
| 12 | Minimum[a] | Minimum | Minimum | Mimimum |
| 13 | Minimum[a] | More than 50 | Minimum | 50 |
| 14 | Minimum[a] | 50 | Minimum | Minimum |
| 15 | Minimum | More than 50 | Minimum | Minimum |
| 16 | Minimum | Minimum | Minimum | Minimum |
| 17 | Minimum | More than 50 | Minimum | Minimum |

[a] *Requires reduction in benthic oxygen demand, which is expected to result if point source controls and minimum diffuse source controls are implemented.*

*Source: SEWRPC.*

Table 40

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE FOX RIVER WATERSHED:[a] 1975

| Pollution Potential Classification | Urban Areas[b] | | Rural Areas[b] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | -- | -- | 95,857 | 17 | 95,857 | 16 |
| High . . . . . | -- | -- | 67,664 | 12 | 67,815 | 11 |
| Moderate. . . | 28,041 | 65 | 135,327 | 24 | 163,217 | 27 |
| Low. . . . . . | 14,124 | 33 | 180,436 | 32 | 194,560 | 32 |
| Very Low . . | 892 | 2 | 84,579 | 15 | 85,471 | 14 |
| Total | 43,057 | 100 | 563,863 | 100 | 606,920 | 100 |

[a] *Includes total areas tributary to the major lakes in the watershed.*

[b] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

The pollution potential classification analysis for the Fox River watershed indicated relatively little variation in urban pollution potential, with 98 percent of the analyzed urban areas receiving a moderate or low rating. Most of the urban areas of significant size outside of direct drainage areas to lakes received a moderate rating, whereas many urban areas which surround lakes in the watershed generally received a low urban pollution potential rating. The rural pollution potential for the Fox River watershed varied significantly in comparison to the rest of the Region. Twenty-nine percent of the rural area is designated by a high or very high rural pollution potential rating, with the areas of highest concern located in Walworth County—specifically the Honey Creek, Sugar Ceek, and Como Creek subwatershed areas. The rural classification indicates that Waukesha County contains the areas of lowest rural pollution potential. The rural pollution potential classification also indicates that some lakes—Beulah, Lulu, North, and Peters Lakes in Walworth County, Spring Lake in Waukesha County, and Long Lake in Racine County—are located in areas of high or very high rural pollution potential.

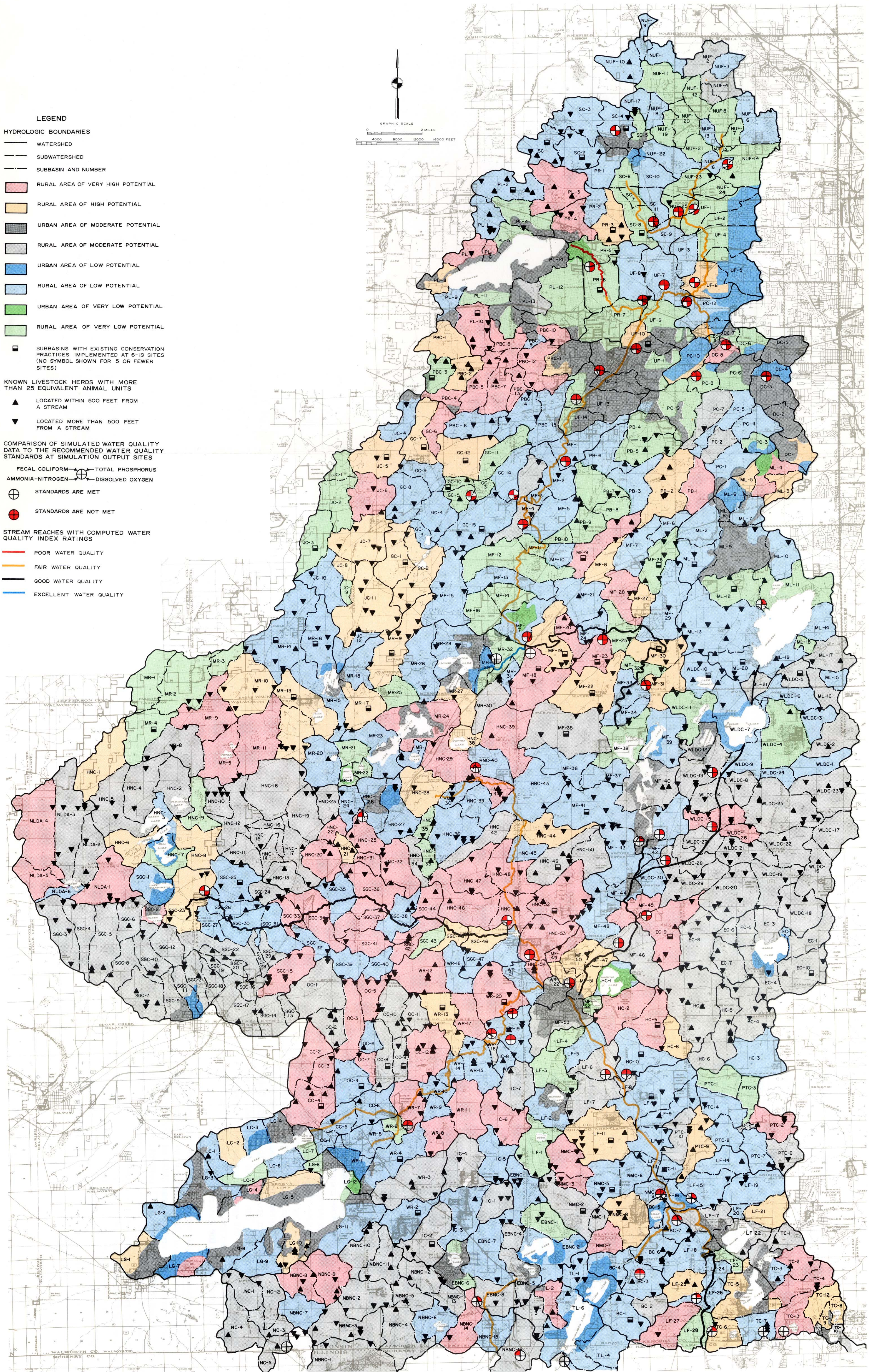
Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Fox River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution and are expected to abate phosphorus problems in Poplar Creek and Deer Creek.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Fox River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding ponds, are needed to sufficiently reduce pollutant loadings from all animal operations. In addition, those animal operations located less than 500 feet from a stream and in high or very high pollution potential areas (see Map 8) may require manure storage through the winter in a dry stacking system incorporating runoff control or a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff. The control of livestock waste runoff, together with the proper management of septic tank systems, is expected to sufficiently alleviate fecal coliform problems in the watershed.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $23.7 million, of which $18.1 million, or 77 percent, would be for urban practices and $5.5 million, or 23 percent, would be for rural practices, and an average annual operation and maintenance cost of $1.0 million, of which $291,000, or 29 percent, would be for urban practices and $716,000, or 71 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 41.

Map 8

DIFFUSE SOURCE POLLUTION POTENTIAL IN THE FOX RIVER WATERSHED: 1975




The hydrologic subbasins in the Fox River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 43,057 acres devoted to urban land uses in the watershed, about 65 percent recorded a moderate potential rating for nonpoint source pollution with the remaining 35 percent recording a low or very low rating. Of the 563,863 acres devoted to rural land uses in the watershed, 29 percent was estimated to have a high or very high potential, 24 percent a moderate potential, and the remaining 47 percent a low or very low potential for nonpoint source pollution. Thus, as of 1975, the Fox River watershed exhibited a moderate potential for urban nonpoint source pollution and a wide range of potential for rural nonpoint source pollution.

*Source: SEWRPC.*

Table 41

ESTIMATED COST OF DIFFUSE SOURCE CONTROL MEASURES FOR THE FOX RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost | |
|---|---|---|
| | Total Capital (1975-2000) | Average Annual Operation and Maintenance |
| Urban | | |
| Septic System Management[a] . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . . . . . . . . . . . | Minimal | 190,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . | 4,271,000 | Minimal |
| Construction Erosion Control Practices . . . . . . . . . . . . | 13,860,000 | 101,000 |
| Subtotal | $18,131,000 | $ 291,000 |
| Rural | | |
| Minimum Conservation Practices[c] . . . | 71,000 | 385,000 |
| Livestock Waste Control . . . . . . . . | 5,478,000 | 331,000 |
| Subtotal | $ 5,549,000 | $ 716,000 |
| Total | $23,680,000 | $1,007,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Fox River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $5,332,000, and an average annual operation and maintenance cost of $375,000.*

[b] *Low-cost urban controls include pet waste and litter control, fertilizer and pesticide use restrictions, public education programs, improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning, and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

Kinnickinnic River Watershed

The water quality of the Kinnickinnic River and its major tributaries was simulated for 51 stream reaches and their associated subbasins, with the results reported and statistically analyzed for three simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The locations of these three simulation sites and the corresponding tributary water quality analysis areas are shown on Map 9 and presented in Table 42. The water quality within combined sewer service area within the Kinnickinnic River watershed was not simulated under the initial areawide water quality management planning program but is being addressed under the Milwaukee Metropolitan Sewerage District pollution abatement program. The following discussion and Figures 44 through 46 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, and fecal coliform are met under existing land use conditions as well as under year 2000 planned land use conditions with point source controls only, and with point source controls coupled with a 25 or a 50 percent reduction in diffuse source pollutant loadings. The streams within the Kinnickinnic River watershed are classified for limited fishery and aquatic life, limited recreational use, and minimum standards.

Temperature: It is apparent from Figures 44 through 46 that the temperature standard of 89°F is satisfied within the Kinnickinnic River watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: No diffuse source controls will be necessary to satisfy the limited fishery and aquatic life dissolved oxygen standard of 3 milligrams per liter (mg/l) within the Kinnickinnic River watershed.

Fecal Coliform: Diffuse source controls are relatively ineffective in reducing the extremely high simulated fecal coliform levels. These high levels are probably caused by leakage or unknown discharges from sanitary sewers. Upon the identification and control of these sources, it is anticipated that only a minimum level of diffuse source controls will be required to satisfy a recreational use standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml).

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Kinnickinnic River watershed indicate that the level of 0.2 mg/l should seldom be exceeded. Diffuse source controls should not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Table 42

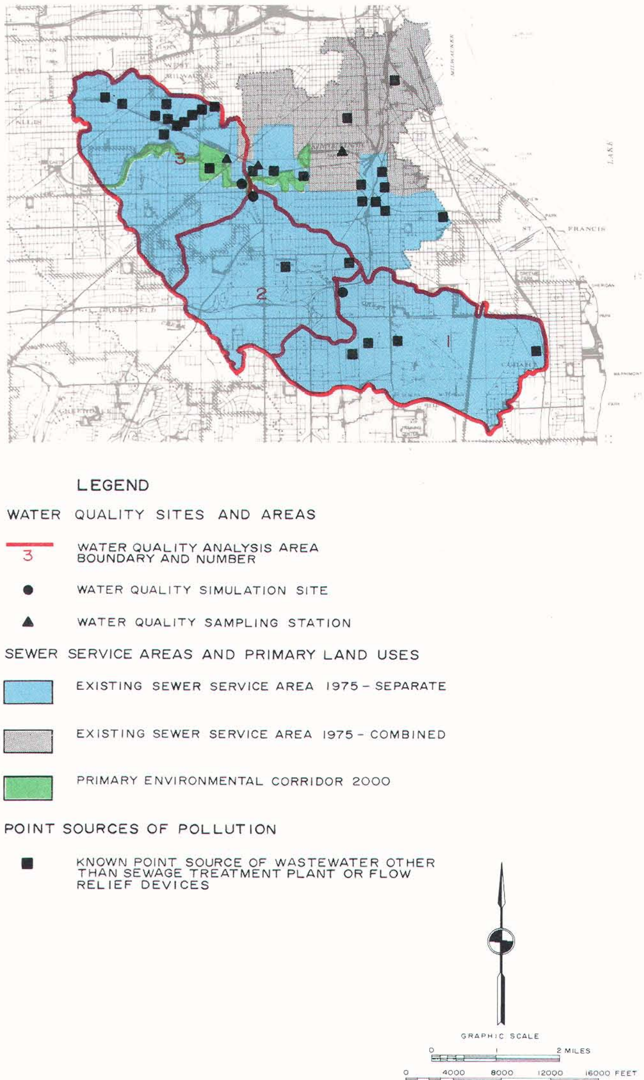
LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE KINNICKINNIC RIVER WATERSHED

| Water Quality Analysis Areas as Presented on Map 9 | Location of Most Downstream Point Draining the Water Quality Analysis Area | |
|---|---|---|
| | Location | U. S. Public Land Survey Designation |
| 1 | Wilson Park Creek City of Milwaukee S. 13th Street | T6N, R22E, Section 20 |
| 2 | City of Milwaukee at the confluence of the Kinnickinnic River | T6N, R21E, Section 12 |
| 3 | Kinnickinnic River City of Milwaukee S. 31st Street | T6N, R21E, Section 12 |

*Source: SEWRPC.*

Map 9

WATER QUALITY ANALYSIS AREAS IN THE KINNICKINNIC RIVER WATERSHED




The Kinnickinnic River watershed has an area of 25 square miles and ranks eleventh in size and fourth in total resident population of the 12 watersheds in the Region. Within the Kinnickinnic River watershed there are 51 identified hydrologic subbasins grouped into three water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are three sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 82 point sources of water pollution—including 52 sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo continued urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 89 and 94 percent of the total watershed area, respectively.

*Source: SEWRPC.*

Summary: Table 43 presents the general level of diffuse source pollutant loading reductions and bottom oxygen demand reductions necessary to satisfy the applicable water quality standards for the Kinnickinnic River watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Kinnickinnic River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 10 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 44 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

Table 43

REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE KINNICKINNIC RIVER WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | |
|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen |
| 1 | Minimum | Minimum[a] | Minimum |
| 2 | Minimum | Minimum[a] | Minimum |
| 3 | Minimum | Minimum[a] | Minimum |

[a] *Diffuse source controls would be relatively ineffective in reducing the extremely high simulated fecal coliform levels. These high fecal coliform levels are probably caused by leakage or unknown discharges from sanitary sewers.*

*Source: SEWRPC.*

Table 44

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE KINNICKINNIC RIVER WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Acres (acres) | Percent of Total Watershed Area |
| Very High . . | 29 | 0 | -- | -- | 29 | -- |
| High . . . . . | 1,131 | 8 | -- | -- | 1,131 | 7 |
| Moderate. . . | 11,389 | 82 | -- | -- | 11,389 | 72 |
| Low. . . . . . | 1,308 | 10 | -- | -- | 1,308 | 8 |
| Very Low . . | -- | -- | 2,048 | 100 | 2,048 | 13 |
| Total | 13,857 | 100 | 2,048 | 100 | 15,905 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

## Figures 44-46

### EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE KINNICKINNIC RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 44

WATER QUALITY ANALYSIS AREA 1

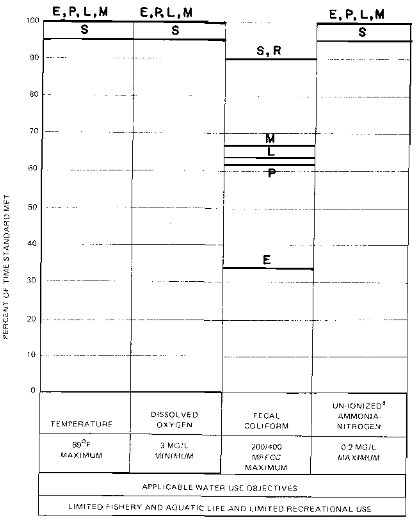



Figure 45

WATER QUALITY ANALYSIS AREA 2

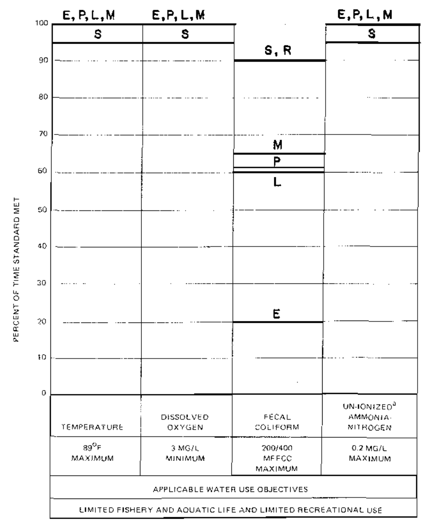
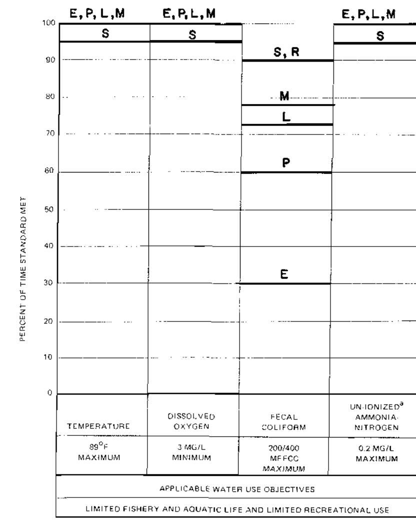



Figure 46

WATER QUALITY ANALYSIS AREA 3




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

L — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AS DEVELOPED IN THE POINT SOURCE ELEMENT OF THIS CHAPTER TO MEET WATER QUALITY STANDARDS AND A LOW (25%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND

R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

*Source: SEWRPC*

The pollution potential classification analysis for the Kinnickinnic River watershed indicated relatively little variation in urban pollution potential, with over 80 percent of the analyzed urban area receiving a moderate rating. The areas of high urban pollution potential were located in the undeveloped portion of Wilson Park Creek. All of the rural area is designated by a very low potential rating.

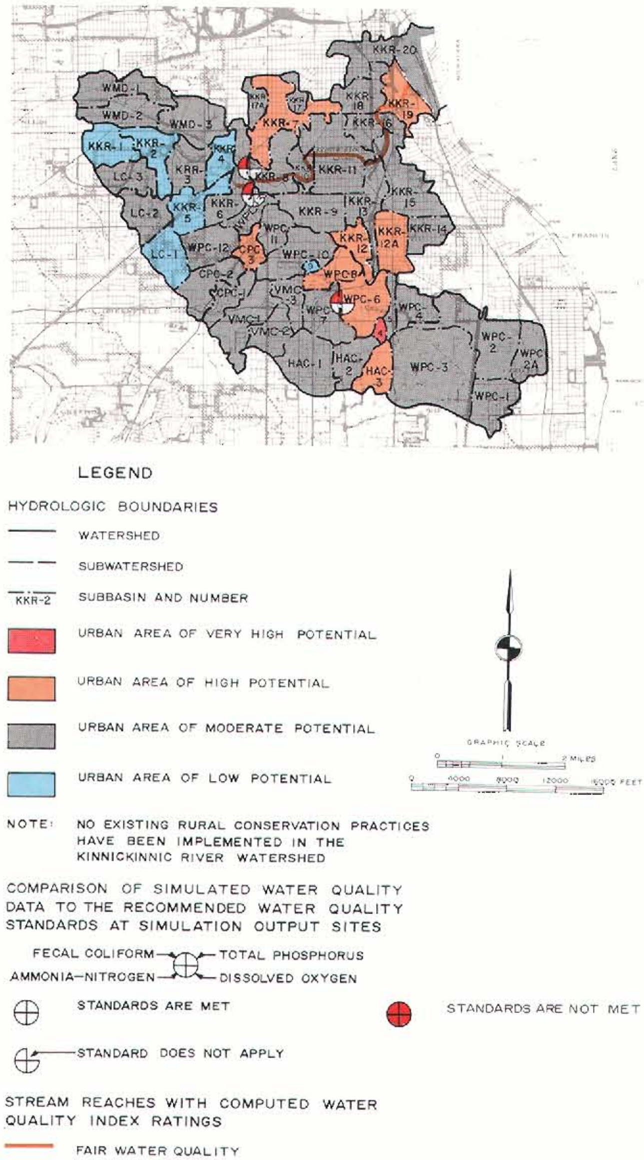
Control of Pollutant Runoff from Urban Land: Minimum low-cost urban diffuse source pollution control practices—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; and critical area protection—are necessary to control urban diffuse source pollution. Construction erosion control practices will be necessary for the abatement of diffuse source pollution and should reduce sediment and phosphorus contributions to the streams. Because of demonstrated toxic conditions in the watershed, industrial and commercial material storage and runoff control facilities are recommended to prevent toxic and hazardous wastes from entering the stream system. Detailed field surveys will be necessary to identify the types, sources, amounts, and control needs for toxic and hazardous wastes in the watershed.

In the combined sewer service area within the watershed, no urban diffuse source control measures have been assumed, since the assumed method for combined sewer overflow abatement is the construction of a deep tunnel conveyance, storage, and treatment system, whereby treatment of storm water runoff would be accomplished. In the event that sewer separation were ultimately chosen for a part of the combined sewer service area, the final diffuse source plan recommendations should be refined as part of the local facilities planning effort being conducted for the sewer service area of the Milwaukee Metropolitan Sewerage District.

Control of Pollutant Runoff from Rural Land: Only about 1,797 acres, or 11 percent, of the watershed were identified as cropland, pasture, or unused rural land as of 1975. Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, and contour plowing—should be implemented to reduce pollutant contributions from the remaining rural land in the watershed.

Map 10

DIFFUSE SOURCE POLLUTION POTENTIAL IN THE KINNICKINNIC RIVER WATERSHED: 1975




The hydrologic subbasins in the Kinnickinnic River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 13,857 acres devoted to urban land uses in the watershed, 8 percent recorded a high or very high pollution potential rating, 82 percent a moderate potential rating, and 10 percent a low potential rating for nonpoint source pollution. All of the 2,048 acres devoted to rural land uses in the watershed were estimated to have a very low potential for nonpoint source pollution. Thus, as of 1975, the Kinnickinnic River watershed exhibited a moderate potential for urban nonpoint source pollution and a very low potential for rural nonpoint source pollution.

*Source: SEWRPC.*

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $2,168,000—essentially all for urban practices—and an average annual operation and maintenance cost of $148,000, of which $145,000, or 98 percent, would be for urban practices and $3,000, or 2 percent, would be for rural practices. The cost estimate for each management practice is summarized in Table 45.

Menomonee River Watershed

The hydrologic-hydraulic-water quality simulation model analyses previously conducted by the Commission and presented in SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, evaluated water quality for 248 stream reaches and the associated subbasins, with the results analyzed and reported for five simulation sites under existing and year 2000 land use conditions with recommended point source controls, and with an estimated reduction in diffuse source loadings. The locations of these five simulation sites and the corresponding tributary water quality analysis areas are shown on Map 11 and presented in Table 46. The following discussion and Figures 47 through 51 present the percent of time the applicable water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, and fecal coliform

Table 45

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE KINNICKINNIC RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Low-Cost Urban Diffuse Source Controls[a] | Minimal | $134,000 |
| Industrial Material Storage and Runoff Control Facilities | 1,018,000 | Minimal |
| Construction Erosion Control Practices | 1,150,000 | 11,000 |
| Subtotal | $2,168,000 | $145,000 |
| Rural | | |
| Minimum Conservation Practices[b] | Minimal | 3,000 |
| Total | $2,168,000 | $148,000 |

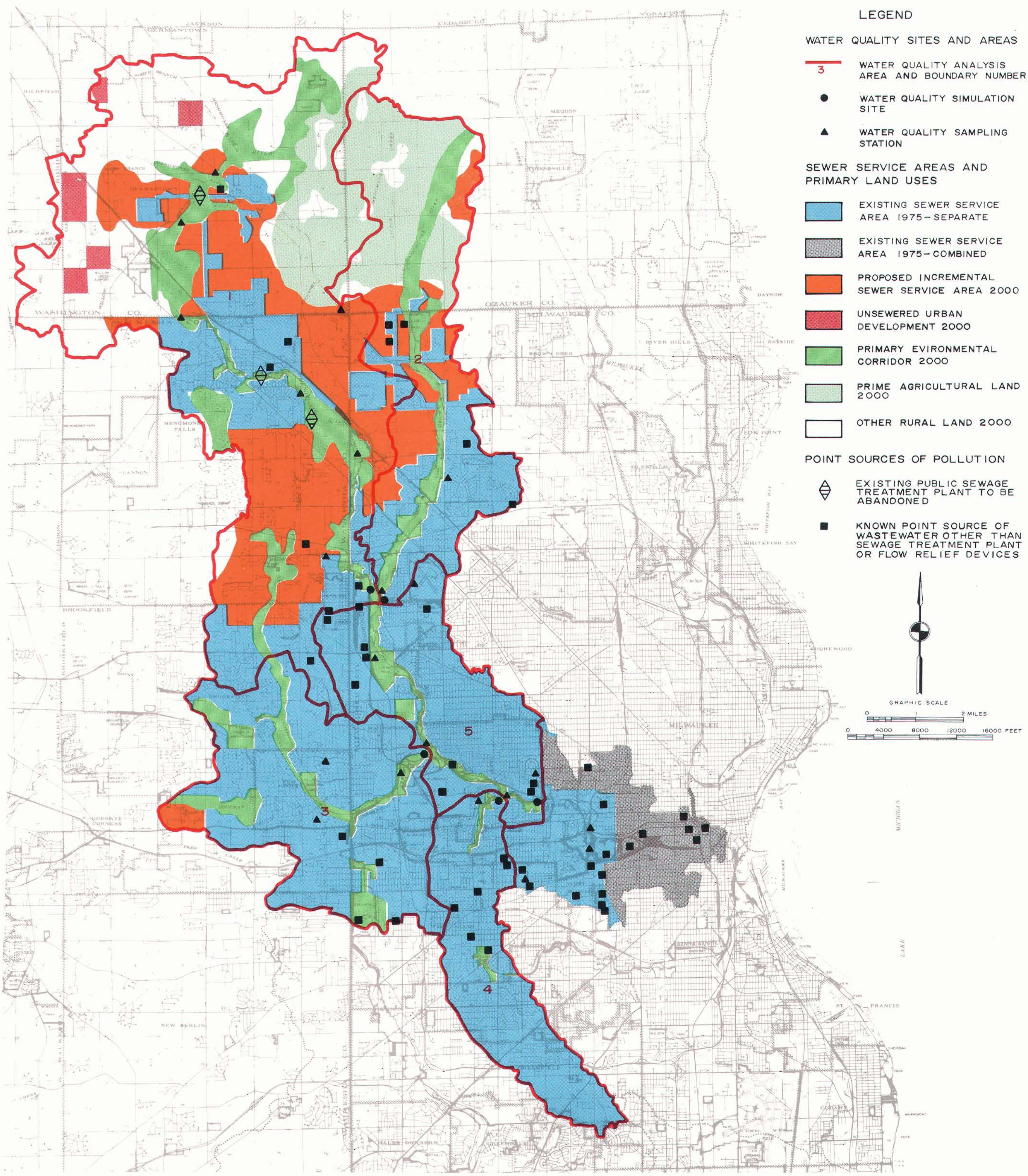
[a] *Low-cost urban controls include pet waste and litter control, fertilizer and pesticide use restrictions, public education programs, improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning, and critical area protection.*

[b] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

## Map 11

## WATER QUALITY ANALYSIS AREAS IN THE MENOMONEE RIVER WATERSHED




The Menomonee River watershed has an area of 136 square miles and ranks fifth in size and second in total resident population of the 12 watersheds in the Region. Within the Menomonee River watershed there are 248 identified hydrologic subbasins grouped into five water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are 20 sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 218 point sources of water pollution—including 166 sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo substantial urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 53 and 62 percent of the total watershed area, respectively.

*Source: SEWRPC.*

Table 46

LOCATION OF WATER QUALITY ANALYSIS AREA IN THE MENOMONEE RIVER WATERSHED

| Water Quality Analysis Areas as Presented on Map 11 | Location of Most Downstream Point Draining the Water Quality Analysis Area | |
|---|---|---|
| | Location | U. S. Public Land Survey Designation |
| 1 | Menomonee River City of Milwaukee, Hampton Avenue west of Lovers Lane, upstream of the confluence with the Little Menomonee River | T8N, R21E, Section 31 |
| 2 | Little Menomonee River City of Milwaukee, Hampton Avenue east of Lovers Lane at the confluence with the Menomonee River | T8N, R21E, Section 31 |
| 3 | Underwood Creek City of Wauwatosa, North Avenue west of Menomonee River Parkway, at the confluence with the Menomonee River | T7N, R21E, Section 20 |
| 4 | Honey Creek City of Wauwatosa, west of 72nd Street and south of State Street, at the confluence with the Menomonee River | T7N, R21E, Section 27 |
| 5 | Menomonee River City of Wauwatosa, Hawley Road, south of State Street | T7N, R21E, Section 27 |

*Source: SEWRPC.*

are met under existing land use conditions as well as under year 2000 planned land use conditions with point source controls only, and with point source controls coupled with a 50 percent reduction in diffuse source pollutant loadings. All streams in the Menomonee River watershed are classified for limited recreational use. In addition, Honey Creek, a portion of Underwood Creek, and the Menomonee River downstream of USH 41 are classified for limited fishery and aquatic life, with the remaining streams designated for warmwater fishery and aquatic life.

Temperature: It is apparent from Figures 47 through 51 that surface water temperatures in the Menomonee River watershed generally exceed the recommended standard 5 to 10 percent of the time in all analysis areas except area 2, which is drained by the Little Menomonee River. The high temperatures are a result of stream channelization which has reduced flow depths and removed stream shading. Neither point source nor diffuse source controls will significantly reduce stream temperatures. Stream channel rehabilitation measures, however, which may increase the shading and water depth of some areas, may be effective in reducing the temperature of the stream system.

Dissolved Oxygen: Under year 2000 conditions with recommended point source controls, the applicable dissolved oxygen standards of 3 milligrams per liter (mg/l) for limited fishery and 5 mg/l for warmwater fishery are met more than 95 percent of the time throughout the the watershed. Diffuse source controls are not expected to be necessary to satisfy the dissolved oxygen standards.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in water quality analysis areas 1 and 5, which are drained by the Menomonee River main stem, indicate that the recommended level for a warmwater fishery of 0.02 mg/l is exceeded approximately 5 percent of the time under year 2000 planned land use conditions without diffuse source controls. Reducing diffuse source ammonia-nitrogen loadings by 50 percent would satisfy the un-ionized ammonia standard in the Menomonee River essentially 100 percent of the time. The tributaries to the Menomonee River do not exceed the applicable un-ionized ammonia-nitrogen standards of 0.02 mg/l for warmwater fishery and 0.2 mg/l for a limited fishery.

Fecal Coliform: All water quality analysis areas within the Menomonee River watershed may be expected to satisfy a fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/ 100 ml) under a diffuse source pollutant loading reduction of 50 percent.

Summary: Table 47 presents the general level of diffuse source pollutant loading reductions necessary to satisfy the applicable water quality standards in the Menomonee River watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended.

Further studies are needed to reevaluate excessive phosphorus levels in the watershed and the water quality of those stream reaches downstream of Hawley Road, which were not analyzed under the Menomonee River watershed study. Forthcoming data from the International Joint Commission's Menomonee River pilot watershed study for the Pollution from Land Use Activities Reference Group and from the Milwaukee Metropolitan Sewerage District's water pollution abatement program will support these further studies under the continuing areawide water quality management planning program.

Table 47

REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE MENOMONEE RIVER WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | |
|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen |
| 1 | Minimum | 50 | Minimum |
| 2 | Minimum | 50 | Minimum |
| 3 | Minimum | 50 | Minimum |
| 4 | Minimum | 50 | Minimum |
| 5 | Minimum | 50 | Minimum |

*Source: SEWRPC.*

## Figures 47-51

### EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE MENOMONEE RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 47

WATER QUALITY ANALYSIS AREA 1

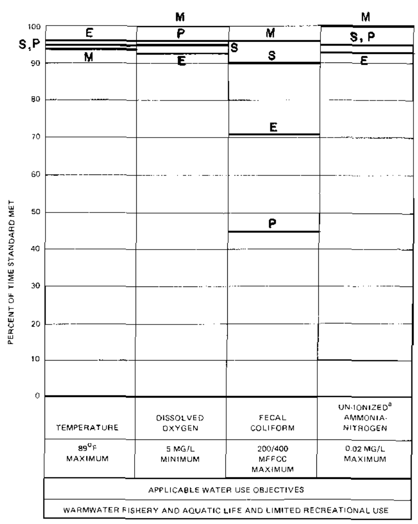



Figure 48

WATER QUALITY ANALYSIS AREA 2

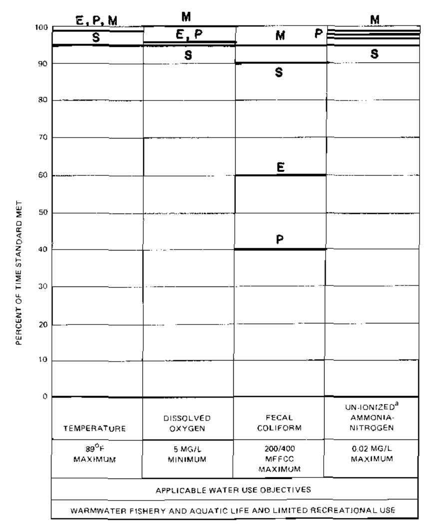



Figure 49

WATER QUALITY ANALYSIS AREA 3

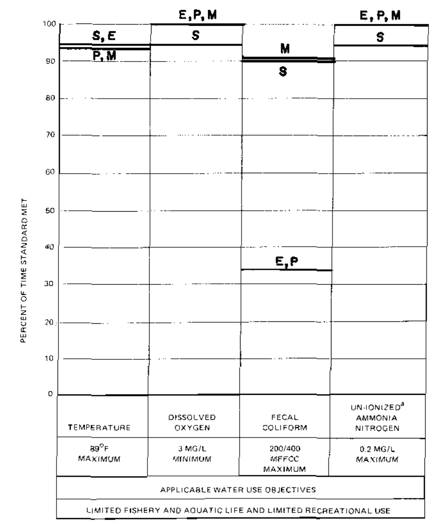



Figure 50

WATER QUALITY ANALYSIS AREA 4

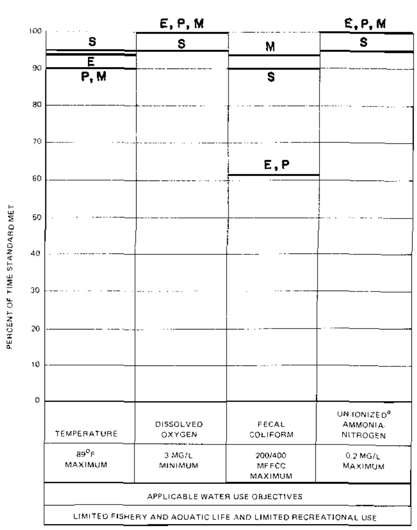
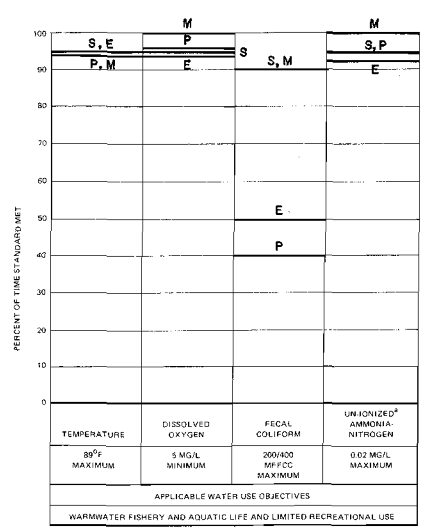



Figure 51

WATER QUALITY ANALYSIS AREA 5




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

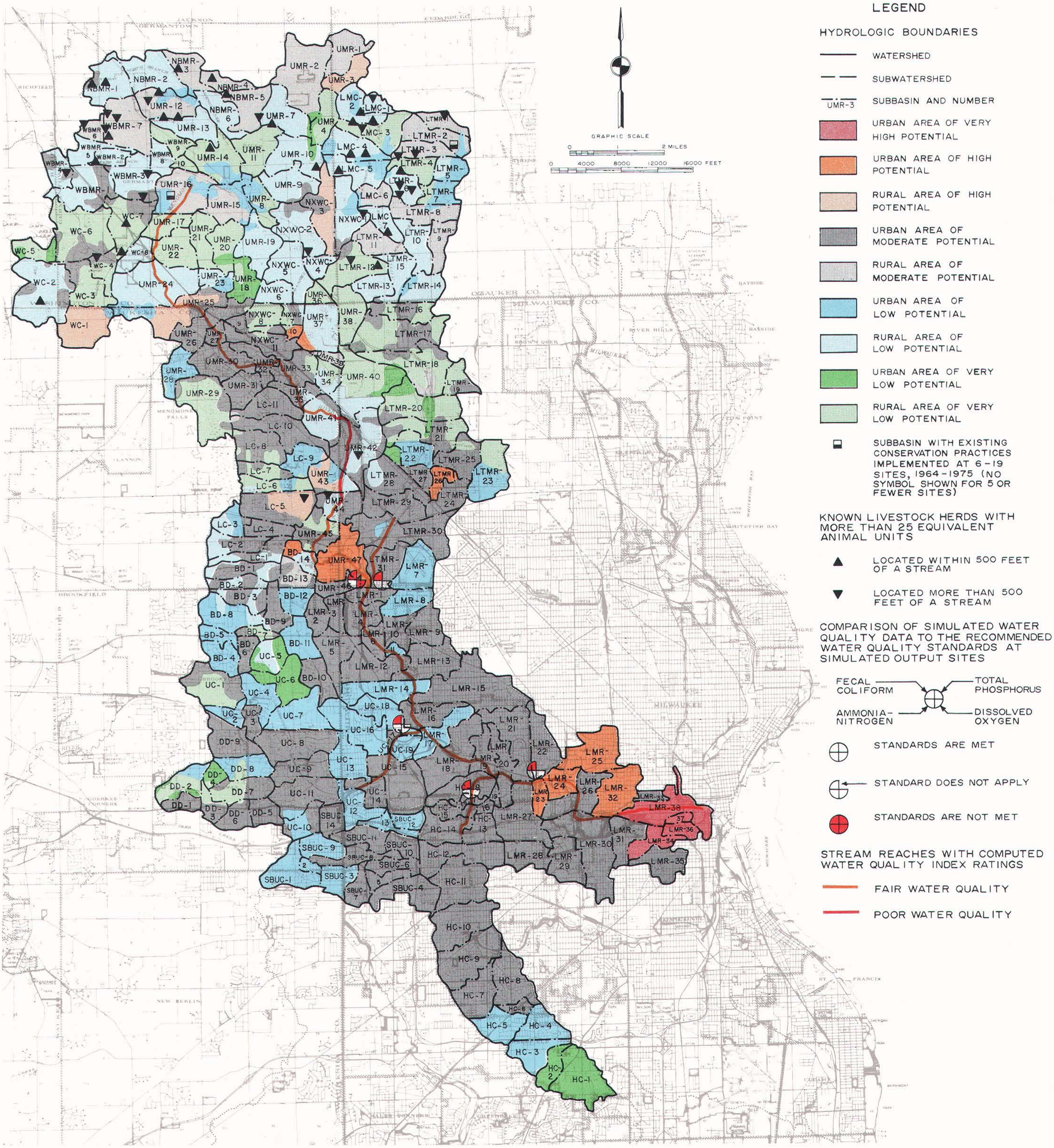
*Source: SEWRPC.*

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Menomonee River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 12 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 48 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

The pollution potential classification analysis for the Menomonee River watershed indicated significant variation compared to the rest of the Region, although 70 percent of the analyzed urban area received a moderate rating. The areas of medium- to high-density residential land use in the Cities of Wauwatosa and West Allis generally received a moderate pollution potential rating. The areas of high and very high pollution potential were located in the Menomonee industrial valley. Less than 10 percent of the rural area in the watershed is designated

Map 12

## DIFFUSE SOURCE POLLUTION POTENTIAL IN THE MENOMONEE RIVER WATERSHED: 1975




The hydrologic subbasins in the Menomonee River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 45,467 acres devoted to urban land uses in the watershed, 6 percent recorded a high or very high pollution potential rating, 70 percent a moderate potential rating, and 24 percent a low or very low potential rating for nonpoint source pollution. Of the 41,535 acres devoted to rural land uses in the watershed, only 6 percent was estimated to have a high or very high potential, 13 percent a moderate potential, and 81 percent a low or very low potential for nonpoint source pollution. Thus, as of 1975, the Menomonee River watershed exhibited a moderate potential for urban nonpoint source pollution and a low potential for rural nonpoint source pollution.

*Source: SEWRPC.*

Table 48

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE MENOMONEE RIVER WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | 936 | 2 | 573 | 1 | 1,509 | 2 |
| High . . . . . | 2,057 | 4 | 2,048 | 5 | 4,105 | 5 |
| Moderate. . . | 31,650 | 70 | 5,459 | 13 | 37,109 | 43 |
| Low. . . . . . | 9,399 | 21 | 17,923 | 43 | 27,322 | 31 |
| Very Low . . | 1,425 | 3 | 15,532 | 38 | 16,957 | 19 |
| Total | 45,467 | 100 | 41,535 | 100 | 87,002 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

by a high or very high pollution potential rating, with greater than 80 percent of the area being classified as having low or very low potential.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices—such as public education programs, litter and pet waste control; proper use of fertilizers and pesticides; industrial and material storage facilities and runoff control measures; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection—are required in the Menomonee River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution.

In the combined sewer service area within the watershed, no urban diffuse source control measures have been assumed, since the assumed method for combined sewer overflow abatement is the construction of a deep tunnel conveyance, storage, and treatment system, whereby treatment of storm water runoff would be accomplished. In the event that sewer separation were ultimately chosen for a part of the combined sewer service area, the final diffuse source plan recommendations should be refined as part of the local facilities planning effort being conducted for the sewer service area of the Milwaukee Metropolitan Sewerage District.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Menomonee River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding facilities, are needed to sufficiently reduce pollutant loadings from all animal operations. Although about 25 percent of the known animal operations in the watershed are located within 500 feet of a stream, very few, if any, operations are located less than 500 feet from a stream and on very high or high pollution potential areas (see Map 12). Therefore, the need to store the manure through the winter in a dry stacking system incorporating runoff control or a liquid or slurry storage system should be minimal in the watershed.

Recommended Measure for Resolution of the Creosote Problem: As documented in SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, a residual creosote pollution problem exists along portions of the Little Menomonee River in Milwaukee County. Although the creosote, which was contributed from an industrial site, has been removed from the bottom of the river upstream of W. Brown Deer Road, it remains in the bottom muds of stream portions downstream of that location and constitutes a potential health hazard to recreational users of the stream and endangers aquatic organisms.

The Commission evaluated four alternative measures for resolving the creosote problem in the Little Menomonee River in Planning Report No. 26: 1) no action; 2) a minimum disturbance approach; 3) the replacement of channel bottom material; and 4) the excavation of a new channel and filling of the existing channel. Following a comparison of the effectiveness and costs of these alternatives, the proposal for excavating a new channel and filling the existing channel was recommended. As of 1978, this pollution problem has not been resolved. Therefore, the above recommendation for resolving the creosote problem in the Little Menomonee River is included in the areawide water quality management plan, and the cost has been updated to 1976 dollars.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $18.8 million, of which $18.4 million, or 98 percent, would be for urban practices and $352,000, or 2 percent, would be for rural practices, and an average annual operation and maintenance cost of $434,000, of which $354,000, or 82 percent, would be for urban practices and $80,000, or 18 percent, would be for rural practices. In addition, the total capital cost for abating creosote pollution in the Little Menomonee River is estimated to be $228,000. The cost estimate for each pollution abatement measure is summarized in Table 49.

Milwaukee River Watershed

The water quality of the Milwaukee River and its major tributaries was simulated for 464 stream reaches and their associated subbasins, with the results reported and statistically analyzed for 38 stream simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The location of these 38 simulation sites and the corresponding tributary water quality analysis areas are shown on Map 13 and presented in Table 50. Since the six simulation sites on Kewaskum Creek were combined into one water quality analysis area, there are only 32 analysis areas. The following discussion and Figures 52 through 84 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized

Table 49

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE MENOMONEE RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost[d] | |
|---|---|---|
| | Total Capital (1975-2000) | Average Annual Operation and Maintenance |
| Urban | | |
| Septic System Management[a] . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b]. . . . . . . . . . . . | Minimal | 262,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . | 5,700,000 | Minimal |
| Construction Erosion Control Practices. . . . . . . . . . . . | 12,699,000 | 92,000 |
| Subtotal | $18,399,000 | $354,000 |
| Rural | | |
| Minimum Conservation Practices[c]. . . | 10,000 | 58,000 |
| Livestock Waste Control . . . . . . . . | 342,000 | 22,000 |
| Subtotal | $ 352,000 | $ 80,000 |
| Total | $18,751,000 | $434,000 |
| Abatement of Creosote Pollution in Little Menomonee River with Excavation of New Channel and Filling of Existing Channel | $ 228,000 | -- |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Menomonee River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $2,983,000, and an average annual operation and maintenance cost of $93,000.*

[b] *Low-cost urban controls include pet waste and litter control, fertilizer and pesticide use restrictions, public education programs, improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning, and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

[d] *These costs differ from those set forth in SEWRPC Planning Report No. 26 as a result of a refinement in the estimated diffuse source control practices and attendant costs required to satisfy the water use objectives and supporting water quality standards.*

*Source: SEWRPC.*

ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as year under 2000 planned land use conditions with point source control only throughout the watershed, and with a 50 percent reduction in diffuse source pollutant loadings in some lower reaches of the watershed. Portions of Lincoln Creek and Indian Creek are classified for limited fishery and aquatic life and limited recreational use. The water use designation for the remaining streams in the Milwaukee River watershed is for warmwater fishery and aquatic life and recreational use.

Table 50

LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE MILWAUKEE RIVER WATERSHED

| Water Quality Analysis Area as Presented on Map 13 | Location of Most Downstream Point Draining the Water Quality Analysis Area | |
|---|---|---|
| | Location | U. S. Public Land Survey Designation |
| | Milwaukee River—Main Stem | |
| 2 | Town of Auburn (Fond du Lac County), west of CTH S | T13N, R19E, Section 33 |
| 3 | Village of Kewaskum, south of STH 28 | T12N, R19E, Section 9 |
| 6 | Town of Kewaskum, north of CTH H | T12 N, R19E, Section 14 |
| 7 | City of West Bend, west of STH 144 | T11N, R19E, Section 2 |
| 9 | City of West Bend, east of Chicago & North Western right-of-way | T11N, R19E, Section 13 |
| 10 | Town of Trenton, north of STH 33 | T11N, R20E, Section 11 |
| 11 | Town of Saukville, south of CTH A | T11N, R21E, Section 6 |
| 13 | Town of Fredonia, north of CTH A | T12N, R21E, Section 30 |
| 14 | Town of Fredonia, south of River Drive | T12N, R21E, Section 28 |
| 15 | Town of Saukville, east of CTH I | T11N, R21E, Section 3 |
| 16 | Village of Saukville, west of CTH W | T11N, R21E, Section 25 |
| 17 | Town of Grafton, north of STH 57 | T10N, R22E, Section 18 |
| 18 | Town of Grafton, south of CTH W | T10N, R21E, Section 36 |
| 24 | Town of Mequon, south of CTH C | T9N, R21E, Section 1 |
| 25 | City of Mequon, east of STH 57 | T9N, R21E, Section 23 |
| 26 | Village of Thiensville, west of STH 57 | T9N, R21E, Section 23 |
| 27 | City of Mequon, east of STH 57 | T9N, R21E, Section 36 |
| 28 | Village of Brown Deer, north of Brown Deer Road | T8N, R21E, Section 1 |
| 32 | City of Glendale, Hampton Avenue west of IH 43 | T8N, R22E, Section 32 |
| 33 | Village of Shorewood, south of Hampton Avenue | T7N, R22E, Section 5 |
| | Milwaukee River—East Branch | |
| 5 | Town of Auburn (Fond du Lac County), east of CTH S | T13N, R19E, Section 35 |
| | Milwaukee River—North Branch | |
| 12 | Town of Farmington, east of CTH X | T12N, R20E, Section 2 |
| | Milwaukee River—West Branch | |
| 1 | Town of Kewaskum, south of Fond du Lac County line west of CTH S | T12N, R19E, Section 4 |
| | Cedar Creek | |
| 19 | Village of Jackson, south of STH 60 | T10N, R20E, Section 20 |
| 20 | Town of Jackson, west of CTH G | T10N, R20E, Section 16 |
| 21 | Town of Jackson, east of CTH M | T10N, R20E, Section 12 |
| 22 | Town of Cedarburg, north of STH 60 | T10N, R21E, Section 14 |
| 23 | Town of Grafton, east of STH 57 | T10N, R21E, Section 36 |
| | Indian Creek | |
| 29 | Village of River Hills, River Road north of Bradley Road | T8N, R22E, Section 7 |
| | Kewaskum Creek | |
| 4 | Village of Kewaskum, east of USH 45 | T12N, R19E, Section 9 |
| | Lincoln Creek | |
| 30 | City of Milwaukee, 45th Street and Congress | T7N, R21E, Section 1 |
| 31 | City of Milwaukee, east of Green Bay Road north of Hampton Avenue | T8N, R22E, Section 31 |
| | Silver Creek | |
| 8 | City of West Bend, west of USH 45 | T11N, R19E, Section 11 |

*Source: SEWRPC.*

Temperature: It is apparent from Figures 52 through 84 that the temperature standard of 89°F is satisfied within the Milwaukee River watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: In general, only minimum diffuse source controls are necessary to satisfy the warmwater fishery and aquatic life dissolved oxygen standard of 5 milligrams per liter (mg/l) within the Milwaukee River watershed. However, dissolved oxygen problems are indicated in the Milwaukee River below Kewaskum, Cedar Creek, Indian Creek, Pigeon Creek, Lincoln Creek, and some lower portions of the Milwaukee River that are downstream of the confluence of the Milwaukee River with Cedar Creek. These problems are caused by high oxygen demand from bottom deposits, and benthic organisms, which are estimated to be mainly attributable to existing and historical contributions from point sources, combined sewer overflows, and diffuse sources. Upon the control of these point sources under plan year 2000 conditions and the implementation of minimum diffuse source controls, it is expected that these bottom deposits will either stabilize or be assimilated by the stream system. If following the implementation of pollution control measures, the benthic oxygen demand is not sufficiently reduced, the possibility of channel dredging activities should be investigated to facilitate the stabilization in some severe areas.

Fecal Coliform: Water quality analysis area 8, which includes the western portion of the City of West Bend and is drained by Silver Creek, and analysis area 29, which is drained by Indian Creek in Milwaukee County, are estimated to require at least an estimated 50 percent reduction in diffuse source fecal coliform loads to satisfy the recreational use fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml). All other areas satisfy the applicable fecal coliform standard without diffuse source controls.

Phosphate-Phosphorus: Following the implementation of the recommended point source controls under plan year 2000 land use conditions, the streams within the Milwaukee River watershed classified for recreational use will satisfy the recommended phosphorus standard of 0.1 mg/l with a minimum level of diffuse source control. In water quality analysis area 2, which is drained by the main stem of the Milwaukee River located outside the Region, minimum diffuse source controls are particularly important to satisfy the phosphorus standard.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Milwaukee River watershed indicate that the warmwater fishery level of 0.02 mg/l is seldom exceeded. Lincoln Creek and Indian Creek do not exceed the limited fishery standard of 0.2 mg/l un-ionized ammonia-nitrogen. Diffuse source controls will not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Summary: Table 51 presents the general level of diffuse source pollutant loading reductions necessary to satisfy the applicable water quality standards for the watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended. In general, a 50 percent reduction in diffuse source fecal coliform loadings is required in some of the urban areas within the watershed. A portion of the watershed located outside the Region requires a slight reduction in diffuse source loads to satisfy the phosphorus standard. All other water quality standards are met with minimum diffuse source controls.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Milwaukee River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 14 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 52

Table 51

**REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE MILWAUKEE RIVER WATERSHED**

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum | Minimum | Minimum | Minimum |
| 2 | Minimum | Minimum | Minimum | Minimum |
| 3 | Minimum | Minimum | Minimum | Minimum |
| 4 | Minimum | Minimum | Minimum | Minimum |
| 5 | Minimum | Minimum | Minimum | Minimum |
| 6 | Minimum[a] | Minimum | Minimum | Minimum |
| 7 | Minimum | Minimum | Minimum | Minimum |
| 8 | Minimum | 50 | Minimum | Minimum |
| 9 | Minimum | Minimum | Minimum | Minimum |
| 10 | Minimum | Minimum | Minimum | Minimum |
| 11 | Minimum | Minimum | Minimum | Minimum |
| 12 | Minimum | Minimum | Minimum | Minimum |
| 13 | Minimum | Minimum | Minimum | Minimum |
| 14 | Minimum | Minimum | Minimum | Minimum |
| 15 | Minimum | Minimum | Minimum | Minimum |
| 16 | Minimum | Minimum | Minimum | Minimum |
| 17 | Minimum | Minimum | Minimum | Minimum |
| 18 | Minimum | Minimum | Minimum | Minimum |
| 19 | Minimum[a] | Minimum | Minimum | Minimum |
| 20 | Minimum[a] | Minimum | Minimum | Minimum |
| 21 | Minimum[a] | Minimum | Minimum | Minimum |
| 22 | Minimum[a] | Minimum | Minimum | Minimum |
| 23 | Minimum[a] | Minimum | Minimum | Minimum |
| 24 | Minimum[a] | Minimum | Minimum | Minimum |
| 25 | Minimum[a] | Minimum | Minimum | Minimum |
| 26 | Minimum[a] | Minimum | Minimum | Minimum |
| 27 | Minimum[a] | Minimum | Minimum | Minimum |
| 28 | Minimum[a] | Minimum | Minimum | Minimum |
| 29 | Minimum[a] | More than 50 | Minimum | Minimum |
| 30 | Minimum[a] | Minimum | Minimum | N/A |
| 31 | Minimum[a] | Minimum | Minimum | N/A |
| 32 | Minimum | Minimum | Minimum | Minimum |
| 33 | Minimum | Minimum | Minimum | Minimum |

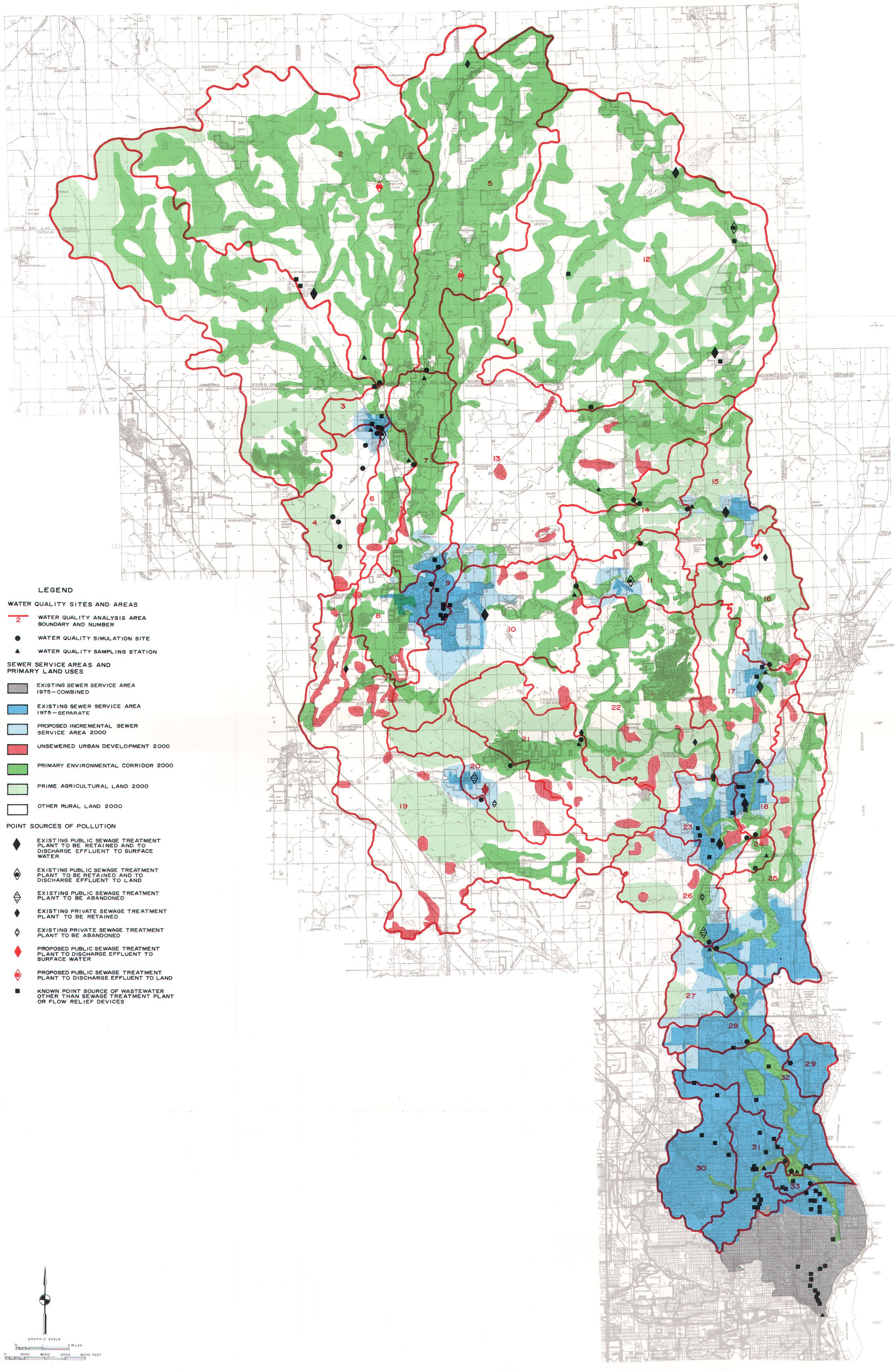
*NOTE: N/A indicates not applicable.*

[a] *Requires reduction in benthic oxygen demand, which is expected to result if point source controls and minimum diffuse source controls are implemented.*

*Source: SEWRPC.*

## Map 13

### WATER QUALITY ANALYSIS AREAS IN THE MILWAUKEE RIVER WATERSHED




The Milwaukee River watershed as studied in the Commission's areawide Water Quality Management Planning Program has an area of 683 square miles. The watershed within the Region ranks third in size and has the highest total resident population of the 12 watersheds in the Region. Within the Milwaukee River watershed there are 464 identified hydrologic subbasins grouped into 33 water quality analysis areas, with 38 stream water quality simulation output sites. Also located within the watershed are 17 sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975, there were 283 point sources of water pollution—including 190 sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. These included 10 point sources of pollution located outside of the Region in Fond du Lac and Sheboygan Counties for which assumptions were made regarding future pollutant loads as described in Appendix C of Volume Three of this report. The watershed is expected to undergo a moderate level of urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 23 and 28 percent of the total watershed area, respectively.

*Source: SEWRPC.*

## EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREA OF THE MILWAUKEE RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 52

WATER QUALITY ANALYSIS AREA 1

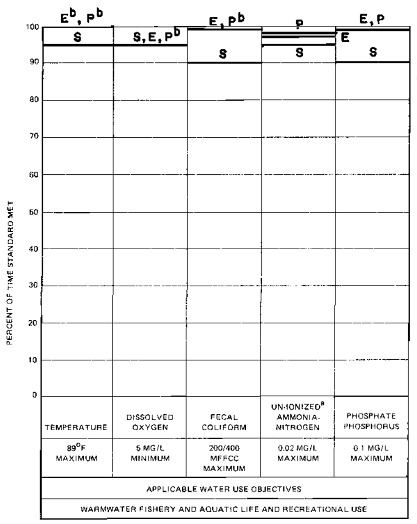


Figure 53

WATER QUALITY ANALYSIS AREA 2

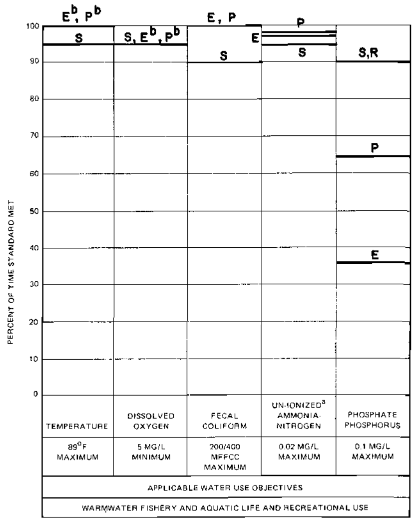


Figure 54

WATER QUALITY ANALYSIS AREA 3

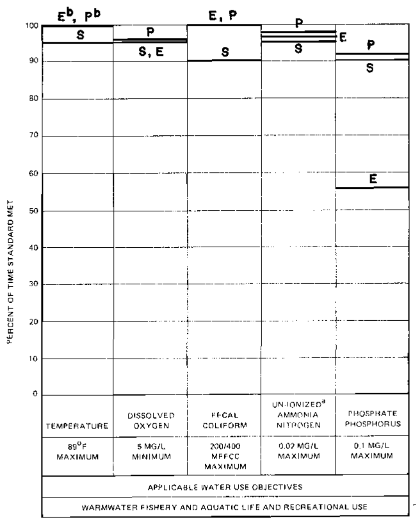


Figure 55

WATER QUALITY ANALYSIS AREA 4

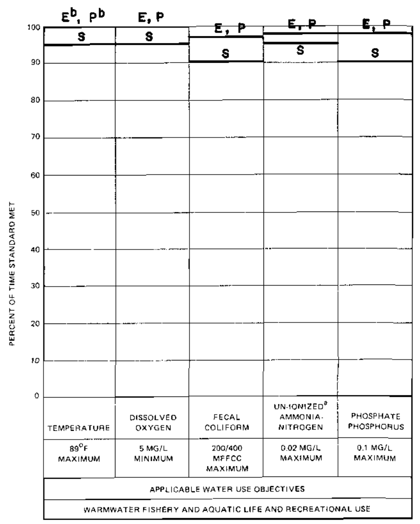


Figure 56

WATER QUALITY ANALYSIS AREA 5

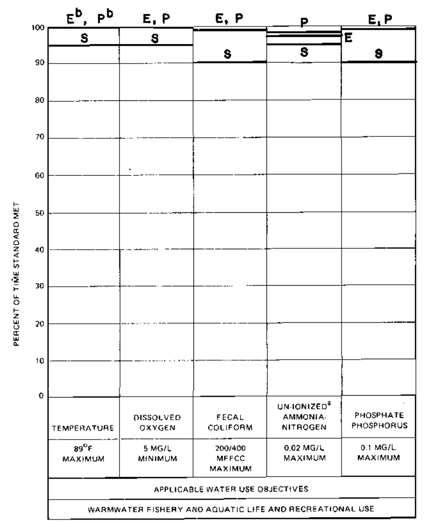


Figure 57

WATER QUALITY ANALYSIS AREA 6

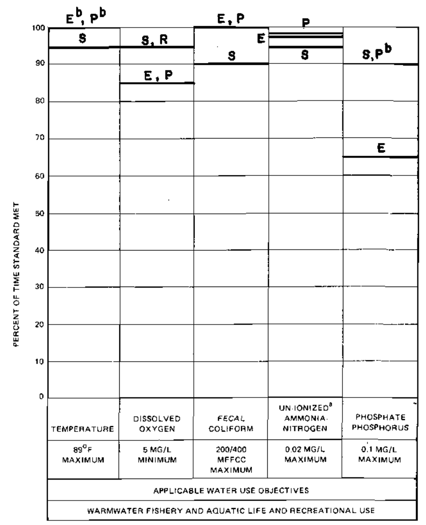


Figure 58

WATER QUALITY ANALYSIS AREA 7

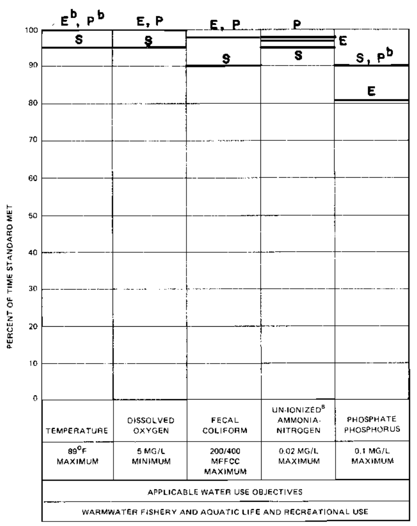


Figure 59

WATER QUALITY ANALYSIS AREA 8

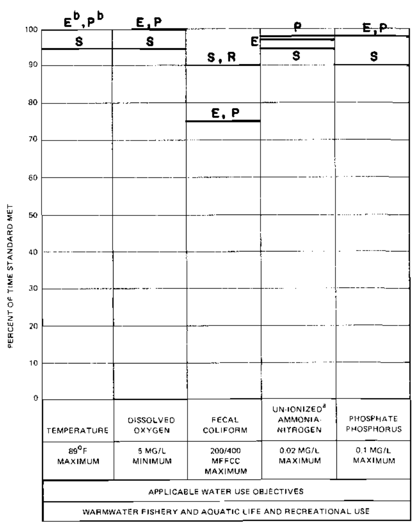


Figure 60

WATER QUALITY ANALYSIS AREA 9

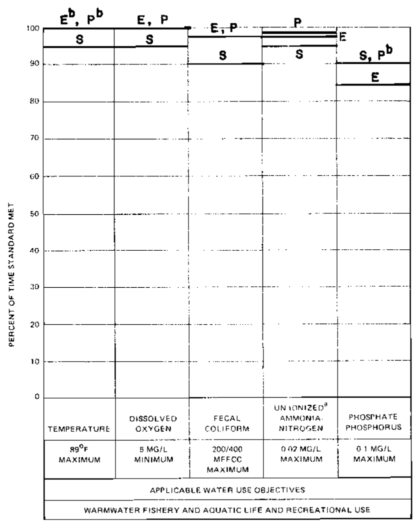


Figure 61

WATER QUALITY ANALYSIS AREA 10

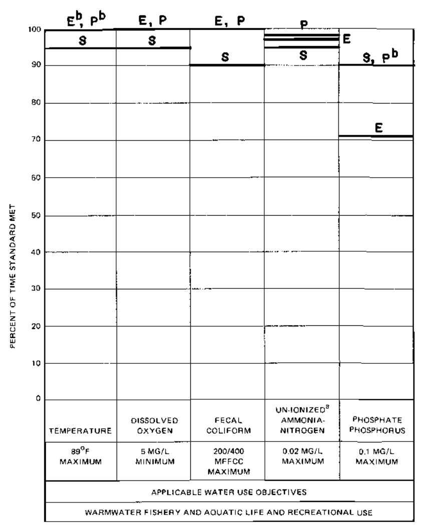


Figure 62

WATER QUALITY ANALYSIS AREA 11

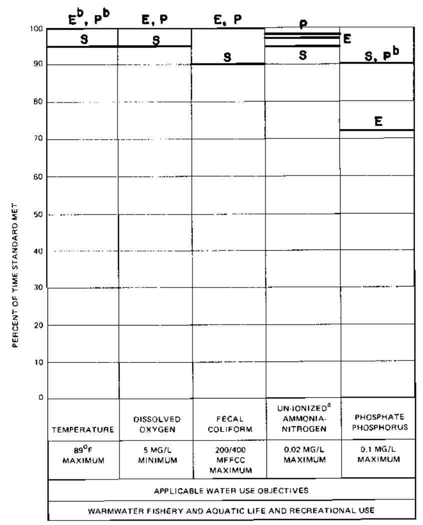


Figure 63

WATER QUALITY ANALYSIS AREA 12

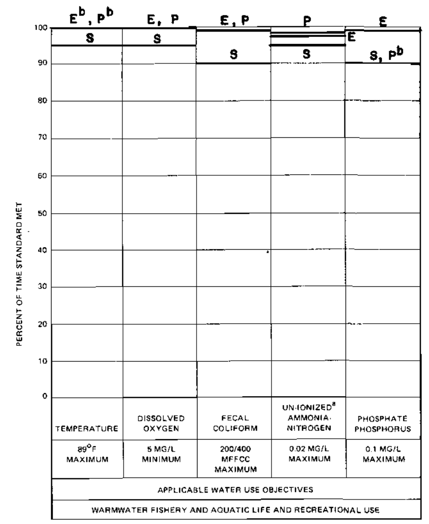


Figure 64

WATER QUALITY ANALYSIS AREA 13

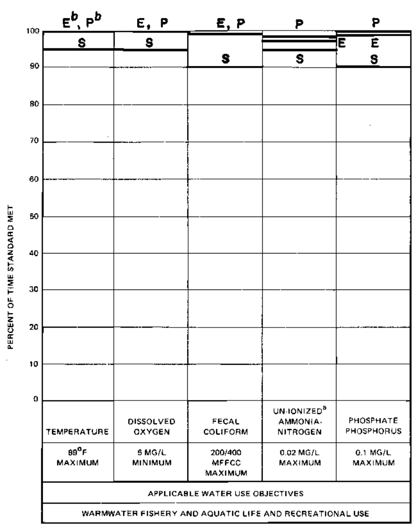


Figure 65

WATER QUALITY ANALYSIS AREA 14

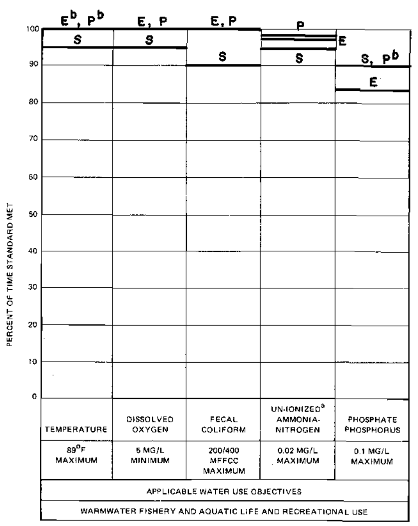


Figure 66

WATER QUALITY ANALYSIS AREA 15

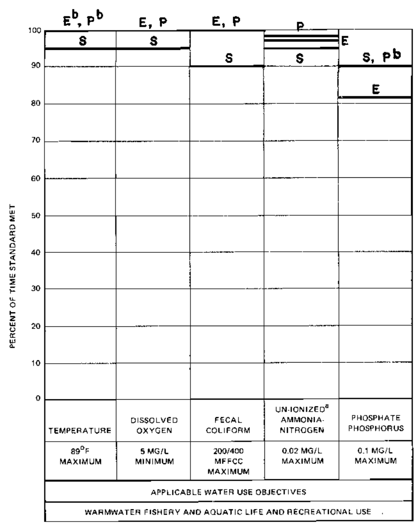


Figure 67

WATER QUALITY ANALYSIS AREA 16

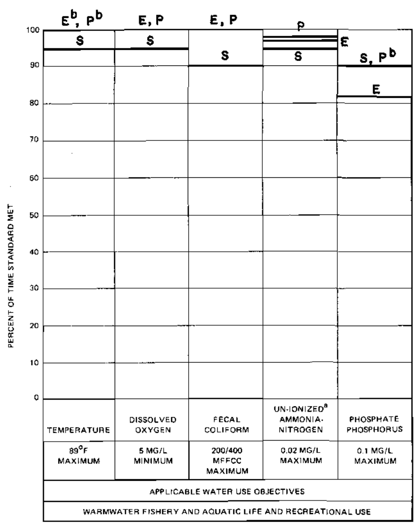
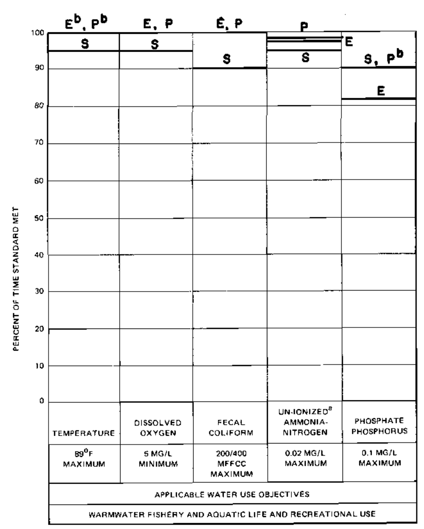


Figure 68

WATER QUALITY ANALYSIS AREA 17



LEGEND

**S** MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

**E** EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

**P** YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**M** YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**R** MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

*Source: SEWRPC.*

## Figures 69-84

# EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE MILWAUKEE RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 69

WATER QUALITY ANALYSIS AREA 18

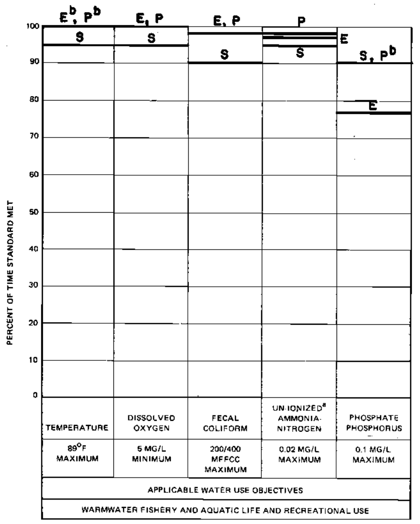



Figure 70

WATER QUALITY ANALYSIS AREA 19

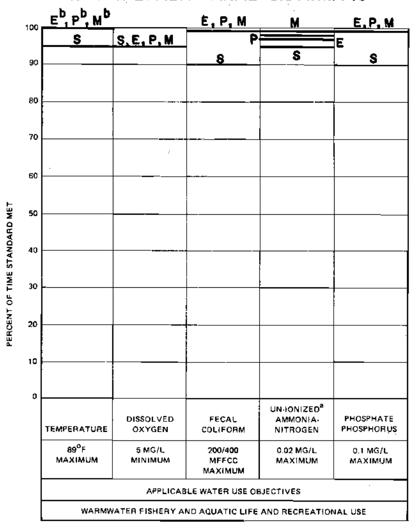



Figure 71

WATER QUALITY ANALYSIS AREA 20

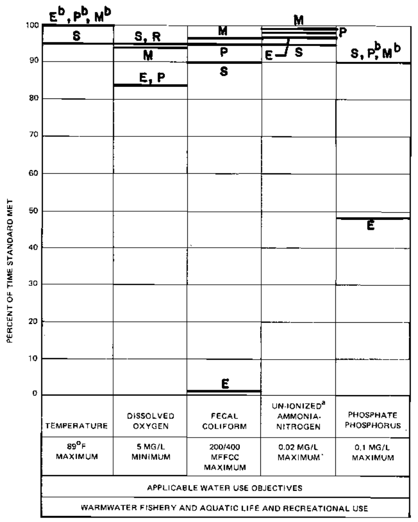



Figure 72

WATER QUALITY ANALYSIS AREA 21

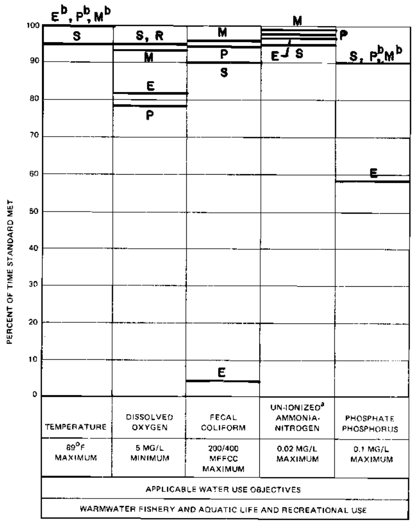



Figure 73

WATER QUALITY ANALYSIS AREA 22

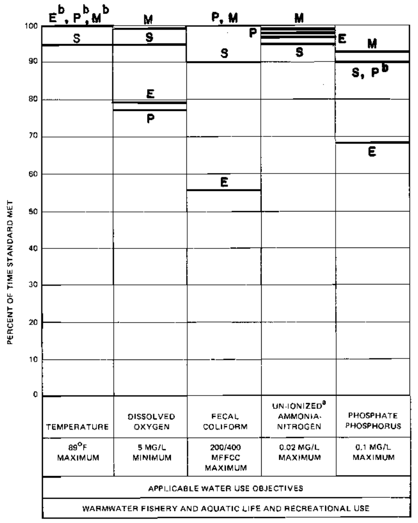



Figure 74

WATER QUALITY ANALYSIS AREA 23

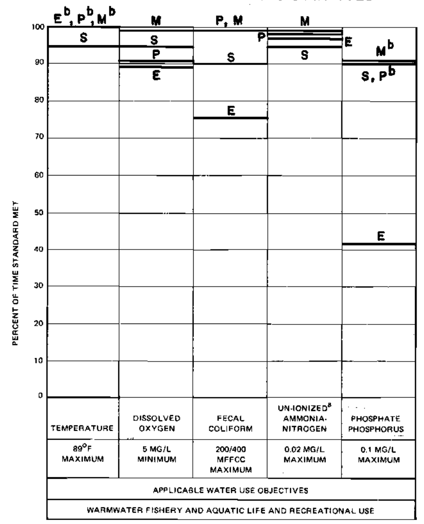



Figure 75

WATER QUALITY ANALYSIS AREA 24

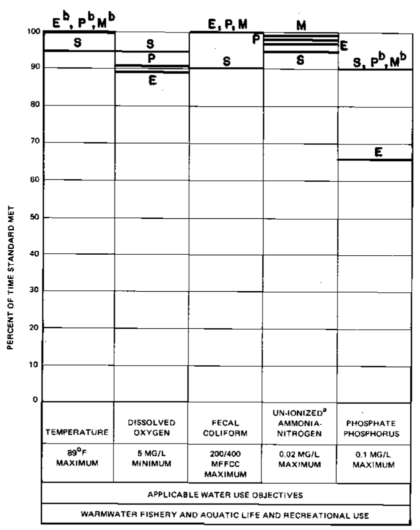



Figure 76

WATER QUALITY ANALYSIS AREA 25

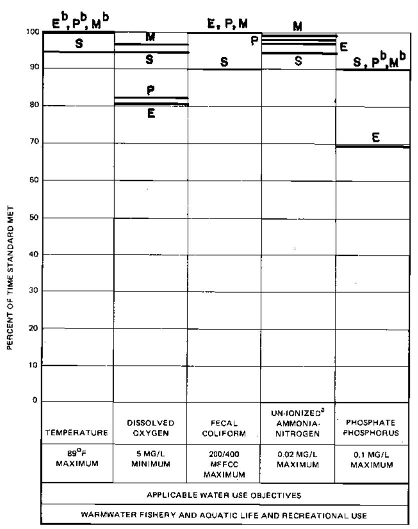



Figure 77

WATER QUALITY ANALYSIS AREA 26

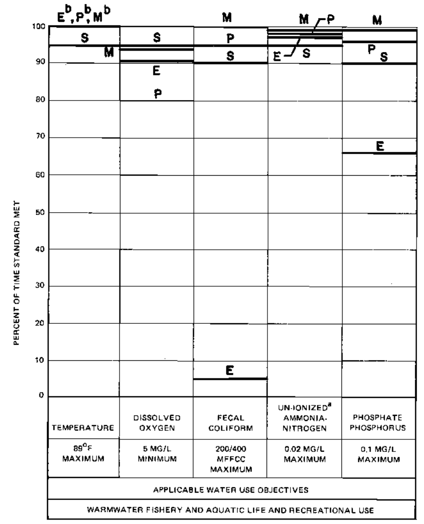



Figure 78

WATER QUALITY ANALYSIS AREA 27

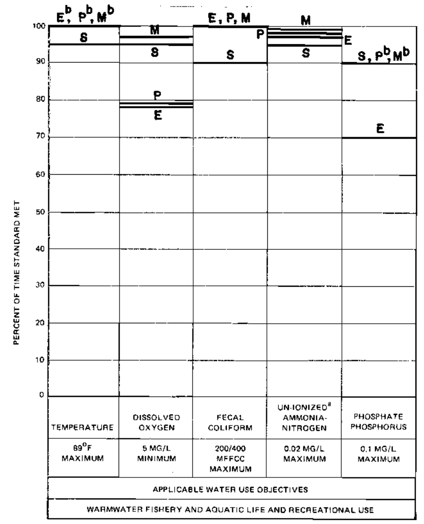



Figure 79

WATER QUALITY ANALYSIS AREA 28

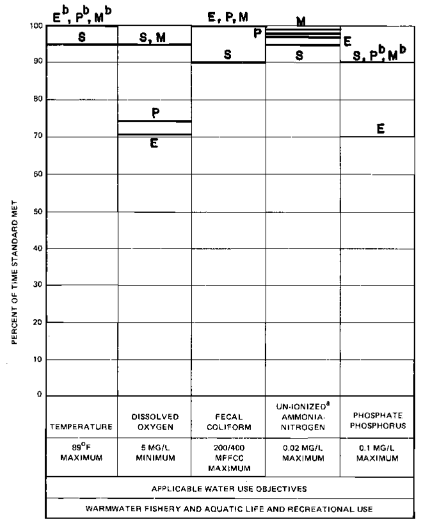



Figure 80

WATER QUALITY ANALYSIS AREA 29

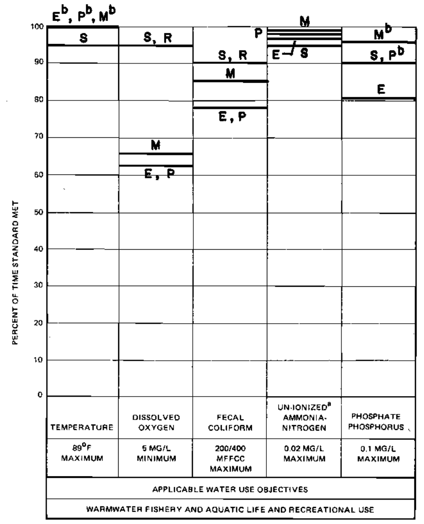



Figure 81

WATER QUALITY ANALYSIS AREA 30

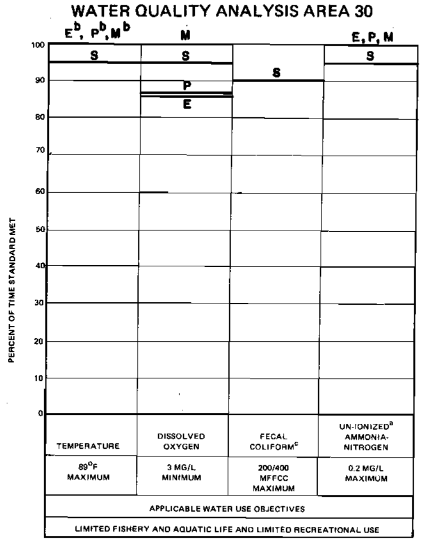



Figure 82

WATER QUALITY ANALYSIS AREA 31

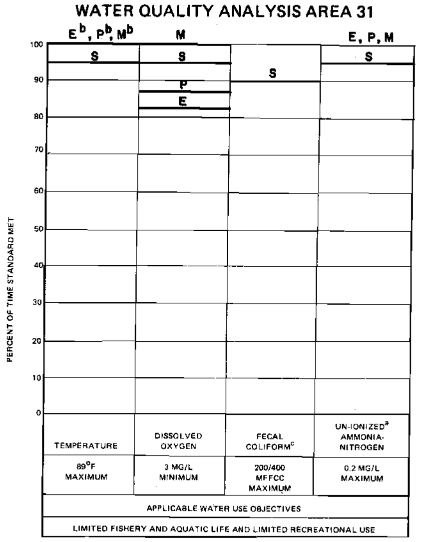



Figure 83

WATER QUALITY ANALYSIS AREA 32

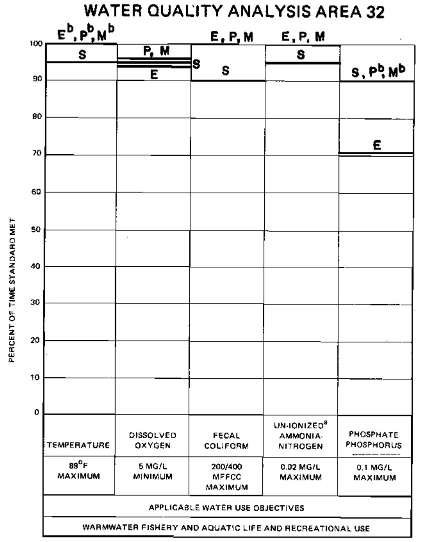
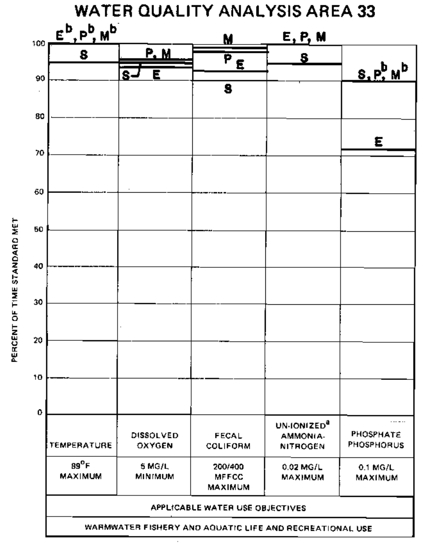



Figure 84

WATER QUALITY ANALYSIS AREA 33




LEGEND

**S** MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

**E** EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

**P** YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**M** YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**R** MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

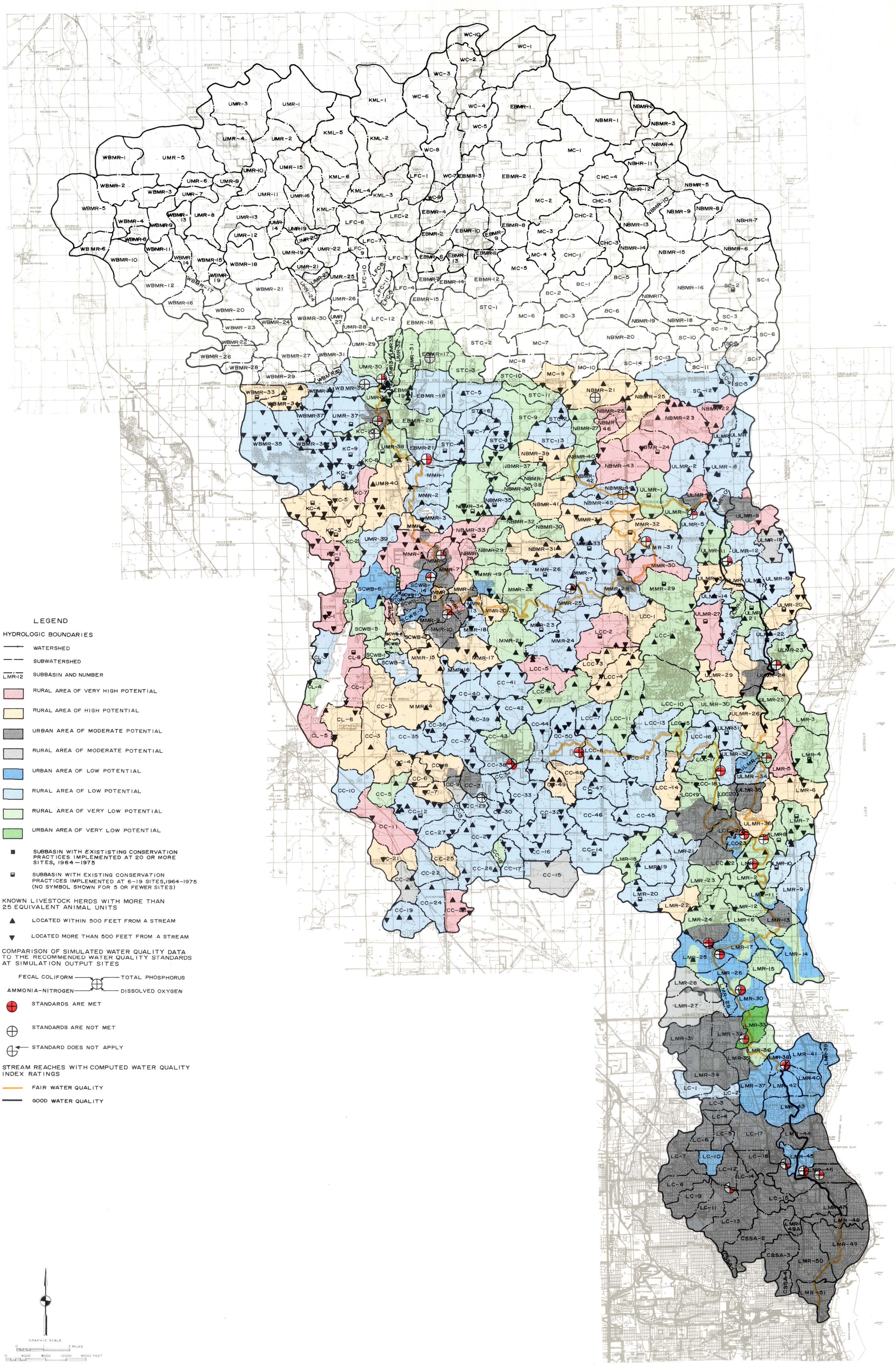
[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

[c] *THE PRECISE CALIBRATION OF FECAL COLIFORM LEVELS WAS NOT POSSIBLE IN ANALYSIS AREAS 30 AND 31, DRAINED BY LINCOLN CREEK, BECAUSE OF EXCESSIVE WET WEATHER FECAL COLIFORM DISCHARGES FROM COMBINED SEWER OVERFLOWS AND/OR SEWAGE FLOW RELIEF DEVICES.*

*Source: SEWRPC.*

Map 14

## DIFFUSE SOURCE POLLUTION POTENTIAL IN THE MILWAUKEE RIVER WATERSHED




The hydrologic subbasins in the Milwaukee River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 43,544 acres devoted to urban land uses in the watershed, more than 70 percent recorded a moderate potential rating for nonpoint source pollution, with virtually all the remainder recording a low or very low rating. Of the 232,499 acres devoted to rural land uses in the watershed, 30 percent of the area was estimated to have a high or very high potential, only 3 percent a moderate potential, and 67 percent a low or very low potential for rural nonpoint source pollution. Thus, as of 1975, the Milwaukee River watershed exhibited a moderate potential for urban nonpoint source pollution and a wide range of potential for rural nonpoint source pollution.

*Source: SEWRPC.*

Table 52

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE MILWAUKEE RIVER WATERSHED:[a] 1975

| Pollution Potential Classification | Urban Areas[b] | | Rural Areas[b] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | -- | -- | 25,119 | 11 | 25,119 | 9 |
| High . . . . | 882 | 2 | 44,757 | 19 | 45,639 | 17 |
| Moderate. . | 30,601 | 71 | 6,523 | 3 | 37,124 | 13 |
| Low. . . . . | 10,608 | 24 | 96,184 | 41 | 106,792 | 39 |
| Very Low . | 1,453 | 3 | 59,916 | 26 | 61,369 | 22 |
| Total | 43,544 | 100 | 232,499 | 100 | 276,043 | 100 |

[a] *Includes total areas tributary to the major lakes in the watershed.*

[b] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

The pollution potential classification analysis for the Milwaukee River watershed indicated relatively little variation in urban pollution potential, with 95 percent of the analyzed urban areas receiving a moderate or low rating. The rural pollution potential varied significantly compared to the rest of the Region. Thirty percent of the rural area is designated by a high or very high rural pollution potential. The rural pollution potential classification also indicated that several lakes in Washington County—Big Cedar Lake, Little Cedar Lake, Lucas Lake, and Lake Twelve—are located in areas of high or very high rural pollution potential. The rural pollution potential classification indicates that areas of low rural pollution potential exist in the southern portion of Ozaukee County, including the Villages of Bayside and Theinsville and the Town of Mequon, in the marsh area within the Town of Saukville, and in the Cedar Creek drainage area in the Town of Jackson.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Milwaukee River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution. The management of onsite sewage disposal systems and low-cost urban control practices is expected to sufficiently alleviate fecal coliform problems in the watershed.

In the combined sewer service area within the watershed, no urban diffuse source control measures have been assumed, since the assumed method for combined sewer overflow abatement is the construction of a deep tunnel conveyance, storage, and treatment system, whereby treatment of storm water runoff would be accomplished. In the event that sewer separation were ultimately chosen for a part of the combined sewer service area, the final diffuse source plan recommendations should be refined as part of the local facilities planning effort being conducted for the sewer service area of the Milwaukee Metropolitan Sewerage District.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Milwaukee River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding ponds, are needed to sufficiently reduce pollutant loadings from all animal operations. In addition, those animal operations located less than 500 feet from a stream and in high or very high pollution potential areas (see Map 14) may require manure storage through the winter in a dry stacking system incorporating runoff control or in a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $28.8 million, of which $24.0 million, or 83 percent, would be for urban practices and $4.8 million, or 17 percent, would be for rural practices, and an average annual operation and maintenance cost of $1.0 million, of which $435,000 or 43 percent, would be for urban practices and $568,000, or 57 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 53.

Minor Streams Tributary to Lake Michigan Watershed

The minor streams tributary to Lake Michigan drain the area adjacent to Lake Michigan which is not drained by the major inland watersheds in the Region. Three such tributaries—Barnes Creek, Pike Creek, and Sucker Creek—are perennial streams large enough to be discussed separately in the following section. Other areas draining directly to Lake Michigan are discussed in the final subsection entitled "Direct Tributary Area to Lake Michigan."

Barnes Creek Subwatershed: The water quality of Barnes Creek was simulated for seven stream reaches and their associated subbasins, with the results reported and statistically analyzed for one simulation site, as shown on Map 15, under existing conditions and under plan year 2000 conditions with various levels of pollution control. The simulation site is located at the confluence with Lake Michigan. The following discussion and Figure 85 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well

Table 53

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE MILWAUKEE RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] | Minimal | 281,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures | 2,475,000 | Minimal |
| Construction Erosion Control Practices | 21,483,000 | 156,000 |
| Subtotal | $23,959,000 | $ 435,000 |
| Rural | | |
| Minimum Conservation Practices[c] | $ 43,000 | $ 276,000 |
| Livestock Waste Control | 4,830,000 | 292,000 |
| Subtotal | $ 4,873,000 | $ 568,000 |
| Total | $28,832,000 | $1,003,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Milwaukee River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $4,050,000, and an average annual operation and maintenance cost of $259,000.*

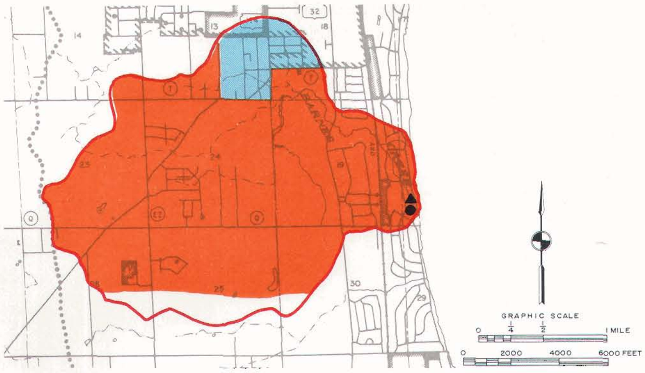
[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

Map 15

WATER QUALITY SIMULATION SITE IN THE BARNES CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED




LEGEND

WATER QUALITY SITES AND AREAS

WATER QUALITY ANALYSIS AREA BOUNDARY

WATER QUALITY SIMULATION SITE

WATER QUALITY SAMPLING STATION

SEWER SERVICE AREAS AND PRIMARY LAND USES

EXISTING SEWER SERVICE AREA 1975—SEPARATE

PROPOSED INCREMENTAL SEWER SERVICE AREA 2000

OTHER RURAL LAND 2000

The Barnes Creek subwatershed has an area of about five square miles. Within the Barnes Creek subwatershed there are seven identified hydrologic subbasins and one water quality simulation output site. Also located within the subwatershed is one site for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were no known point sources of water pollution in the subwatershed to be considered in the water quality analyses. The subwatershed is expected to undergo substantial urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 37 and 62 percent of the total subwatershed area, respectively.

*Source: SEWRPC.*

as under year 2000 planned land use conditions. Barnes Creek is classified for warmwater fishery and aquatic life and recreational use.

*Temperature:* It is apparent from Figure 85 that the temperature standard of 89°F is satisfied within the Barnes Creek subwatershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

*Dissolved Oxygen:* An estimated 25 to 50 percent reduction in diffuse source loads will be necessary to achieve the warmwater fishery and aquatic life standard of 5 milligrams per liter (mg/l) on Barnes Creek.

*Fecal Coliform:* The Barnes Creek subwatershed will require an estimated 75 percent reduction in diffuse source loads to satisfy a fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml) under year 2000 conditions.

*Un-ionized Ammonia-Nitrogen:* An un-ionized ammonia-nitrogen standard of 0.02 mg/l is expected to be satisfied in the Barnes Creek subwatershed without diffuse source controls.

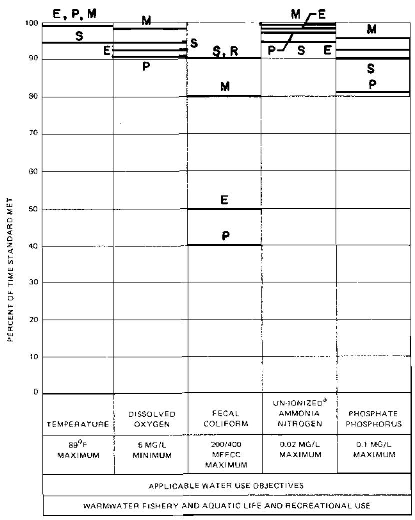
*Phosphate-Phosphorus:* A phosphorus standard of 0.1 mg/l should be met with a 50 percent reduction in diffuse source loadings.

*Summary:* Table 54 presents the general level of diffuse source pollutant loading reductions necessary to satisfy the applicable water quality standards for the Barnes Creek subwatershed. Required reduction values are shown for each pollutant for which a standard has been recommended. In general, a 50 percent reduction in diffuse source loads will be required to meet the water use objectives, although about 75 percent of the fecal coliform loads will need to be abated.

*Identification of Pollution Priority Problem Areas:* The hydrologic subbasins in the Barnes Creek subwatershed were classified according to selected criteria which

Figure 85

**EXPECTED WATER QUALITY STANDARD ACHIEVEMENT IN THE BARNES CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL**




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

*Source: SEWRPC.*

indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 16 indicates the areal extent of the various levels of diffuse source pollution potential in the subwatershed, and Table 55 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

Table 54

**REQUIRED DIFFUSE SOURCE CONTROL LEVELS IN THE BARNES CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED**

| Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|
| Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 50 | 75 | Minimum | 50 |

*Source: SEWRPC.*

The pollution potential classification analysis for the Barnes Creek subwatershed indicated relatively little variation in urban pollution potential, with all of the analyzed urban areas receiving a moderate or low rating. The rural classification indicated a similar range in potential, with all of the analyzed rural areas receiving a low or very low rating.

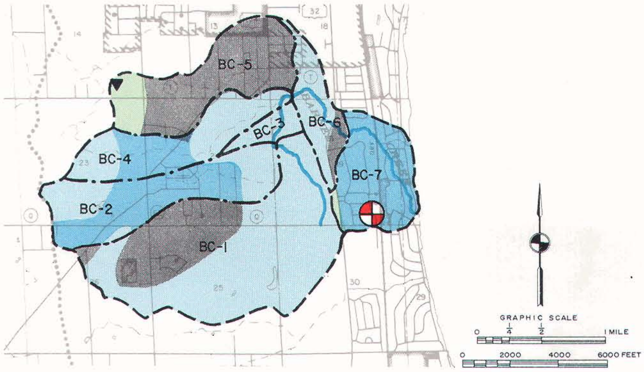
*Control of Pollutant Runoff from Urban Land:* Low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Barnes Creek subwatershed. Material storage and runoff control, which is anticipated to be primarily funded by private expenditures, is a necessary pollution abatement measure for the Barnes Creek subwatershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution. These urban practices alone, however, are not anticipated to provide a sufficient level of urban diffuse source pollution control in the Barnes Creek subwatershed. Many other measures will need to be instituted, including improved street sweeping practices, with improved vacuum sweepers, increased sweeping frequencies, and the enactment of parking ordinances; streambank protection measures; improved street maintenance and refuse collection and disposal; improved and more frequent leaf collection with vacuum sweepers; and increased catch basin cleaning in existing areas with vacuum cleaners.

*Control of Pollutant Runoff from Rural Land:* Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of Barnes Creek. No known major livestock operations exist in the subwatershed.

*Cost Estimate:* Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $1.6 million,

## Map 16

### DIFFUSE SOURCE POLLUTION POTENTIAL IN THE BARNES CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED




LEGEND

HYDROLOGIC BOUNDARIES

— — SUBWATERSHED

BC-1 SUBBASIN AND NUMBER

URBAN AREA OF MODERATE POTENTIAL

URBAN AREA OF LOW POTENTIAL

RURAL AREA OF LOW POTENTIAL

RURAL AREA OF VERY LOW POTENTIAL

NOTE: NO EXISTING RURAL CONSERVATION PRACTICES HAVE BEEN IMPLEMENTED IN THE BARNES CREEK WATERSHED

KNOWN LIVESTOCK HERDS WITH MORE THAN 25 EQUIVALENT ANIMAL UNITS

▼ LOCATED MORE THAN 500 FEET FROM A STREAM

COMPARISON OF SIMULATED WATER QUALITY DATA TO THE RECOMMENDED WATER QUALITY STANDARDS AT SIMULATION OUTPUT SITES

FECAL COLIFORM — TOTAL PHOSPHORUS

AMMONIA-NITROGEN — DISSOLVED OXYGEN

STANDARDS ARE MET

STANDARDS ARE NOT MET

STREAM REACHES WITH COMPUTED WATER QUALITY INDEX RATINGS

GOOD WATER QUALITY

The hydrologic subbasins in the Barnes Creek subwatershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 1,065 acres devoted to urban land uses in the subwatershed, 62 percent recorded a moderate potential rating for nonpoint source pollution, with the remaining 38 percent recording a low rating. The approximately 1,815 acres devoted to rural land uses in the subwatershed were all estimated to have a low or very low potential for nonpoint source pollution. Thus, as of 1975, the Barnes Creek subwatershed exhibited a moderate potential for urban nonpoint source pollution and a low potential for rural nonpoint source pollution.

*Source: SEWRPC.*

of which nearly all would be for urban practices, and an average annual operation and maintenance cost of $102,000, of which $99,000, or 97 percent, would be for urban practices and $3,000, or 3 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 56.

## Table 55

### AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE BARNES CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Subwatershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Subwatershed Area |
| Very High . . | -- | -- | -- | -- | -- | -- |
| High . . . . . | -- | -- | -- | -- | -- | -- |
| Moderate. . . | 660 | 62 | -- | -- | 660 | 23 |
| Low. . . . . . | 405 | 38 | 1,561 | 86 | 1,966 | 68 |
| Very Low . . | -- | -- | 254 | 14 | 254 | 9 |
| Total | 1,065 | 100 | 1,815 | 100 | 2,880 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

Pike Creek Subwatershed: The water quality of Pike Creek was simulated for four stream reaches and their associated subbasins, with the results reported and statistically analyzed for one simulation site, as shown on Map 17, under existing conditions and under plan year 2000 conditions with various levels of pollution control. The simulation site is located at the confluence with Lake Michigan. While much of Pike Creek is enclosed in an underground channel, some portions of the stream—particularly within the Washington Municipal Park area and those stream reaches upstream of STH 43 and 30th Avenue—have not undergone major channelization. These stream reaches may support full warmwater fishery and aquatic life communities and recreational use. Figure 86 and Table 57 characterize the potential for Pike Creek to satisfy recreational use and warmwater fishery and aquatic life water use objectives and supporting standards for temperature, dissolved oxygen, fecal coliform, un-ionized ammonia-nitrogen, and phosphorus under various levels of pollution control. All standards are satisfied under year 2000 land use conditions without diffuse source controls except that for fecal coliform, which will require a 50 percent reduction in diffuse source loads. To protect those limited areas suitable for warmwater fish and aquatic life, the water use classification for Pike Creek is for warmwater fishery and aquatic life and recreational use. Diffuse source controls should be implemented to control fecal coliform contributions to Pike Creek.

*Identification of Pollution Priority Problem Areas:* The hydrologic subbasins in the Pike Creek subwatershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 18 indicates the areal extent of the various levels of diffuse source pollution potential in the subwatershed, and Table 58 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

## Table 56

### ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE BARNES CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] . . . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . . . . . . . . . . . . . | Minimal | 6,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . . . . . . | 17,000 | Minimal |
| Additional Urban Diffuse Source Controls[c] . . . . . . . . . . . . . . | 106,000 | 82,000 |
| Construction Erosion Control Practices . . | 1,499,000 | 11,000 |
| Subtotal | $1,622,000 | $ 99,000 |
| Rural | | |
| Minimum Conservation Practices[d] . . . . . | Minimal | $ 3,000 |
| Total | $1,622,000 | $102,000 |

[a] *The proper maintenance of the remaining septic tank systems until the provision of sanitary sewer service is recommended to help improve the water quality of the Barnes Creek subwatershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include an average annual operation and maintenance cost prior to the provision of sanitary sewer service of $11,000.*

[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

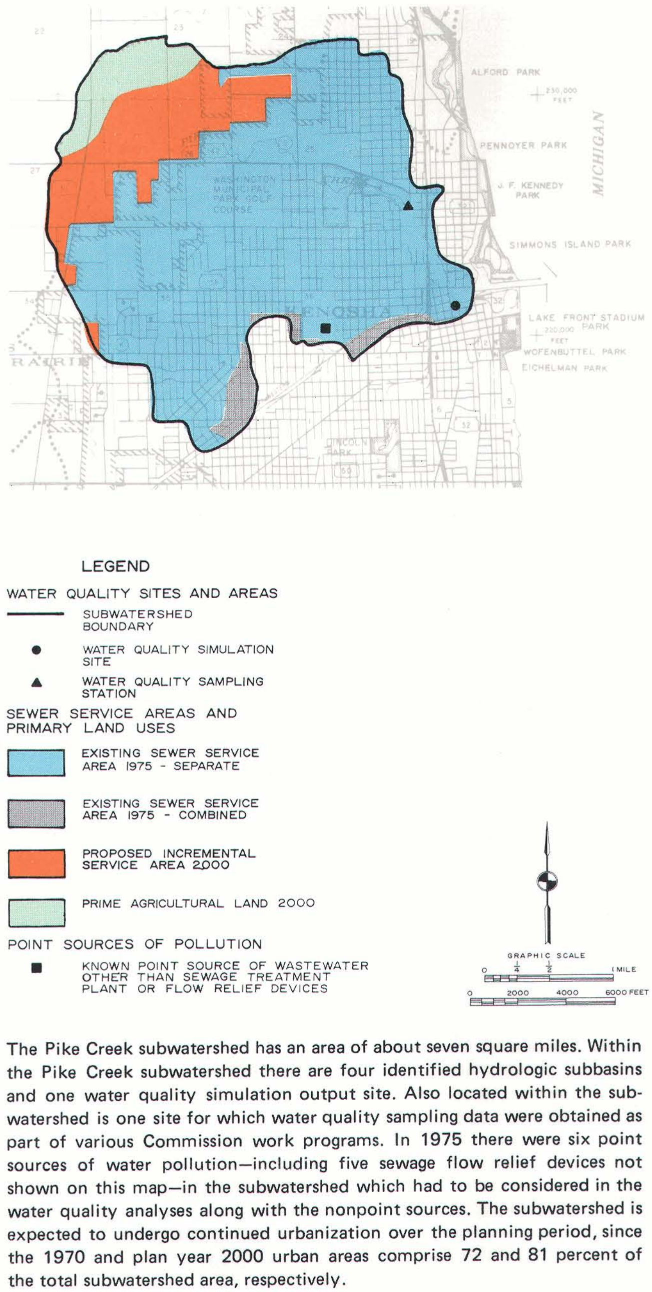
[c] *Additional urban practices necessary to achieve a further 50 percent reduction in urban diffuse source loadings include increased street sweeping, increased leaf and vegetative debris collection and disposal, increased catch basin cleaning, and improved street maintenance and refuse collection.*

[d] *Minimum conservation practices include, crop residue management, chisel tillage, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

## Map 17

### WATER QUALITY SIMULATION SITE IN THE PIKE CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED




The Pike Creek subwatershed has an area of about seven square miles. Within the Pike Creek subwatershed there are four identified hydrologic subbasins and one water quality simulation output site. Also located within the subwatershed is one site for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were six point sources of water pollution—including five sewage flow relief devices not shown on this map—in the subwatershed which had to be considered in the water quality analyses along with the nonpoint sources. The subwatershed is expected to undergo continued urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 72 and 81 percent of the total subwatershed area, respectively.

*Source: SEWRPC.*

## Table 57

### REQUIRED DIFFUSE SOURCE CONTROL LEVELS IN THE PIKE CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

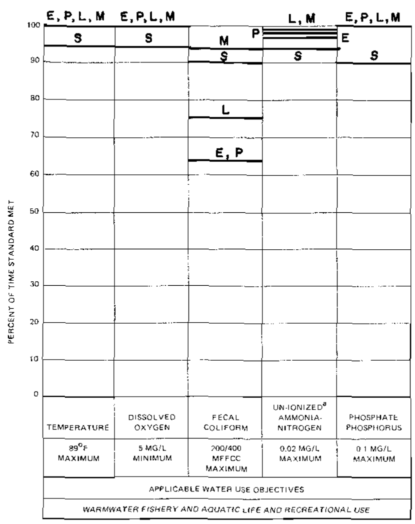
| Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|
| Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| Minimum | 50 | Minimum | Minimum |

*Source: SEWRPC.*

The pollution potential classification analysis for the Pike Creek subwatershed indicated a moderate rating for all of the analyzed urban area. The analyzed urban area consisted of the portion of the City of Kenosha within the subwatershed. The rural classification indicated a low or very low pollution potential rating for all of the analyzed areas.

Figure 86

EXPECTED WATER QUALITY STANDARD ACHIEVEMENT IN THE PIKE CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

L — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AS DEVELOPED IN THE POINT SOURCE ELEMENT OF THIS CHAPTER TO MEET WATER QUALITY STANDARDS AND A LOW (25%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

*Source: SEWRPC.*

Table 58

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE PIKE CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Subwatershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Subwatershed Area |
| Very High . . | -- | -- | -- | -- | -- | -- |
| High . . . . . | -- | -- | -- | -- | -- | -- |
| Moderate. . . | 3,586 | 100 | -- | -- | 3,586 | 79 |
| Low. . . . . . | -- | -- | 237 | 25 | 237 | 5 |
| Very Low . . | -- | -- | 721 | 75 | 721 | 16 |
| Total | 3,586 | 100 | 958 | 100 | 4,544 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Pike Creek subwatershed. Construction erosion control practices will also be necessary for the abatement of diffuse source pollution. The elimination of septic systems through the provision of sanitary sewer service to the entire subwatershed—along with the miminum level of control of urban runoff—should alleviate the fecal coliform problem in the subwatershed.

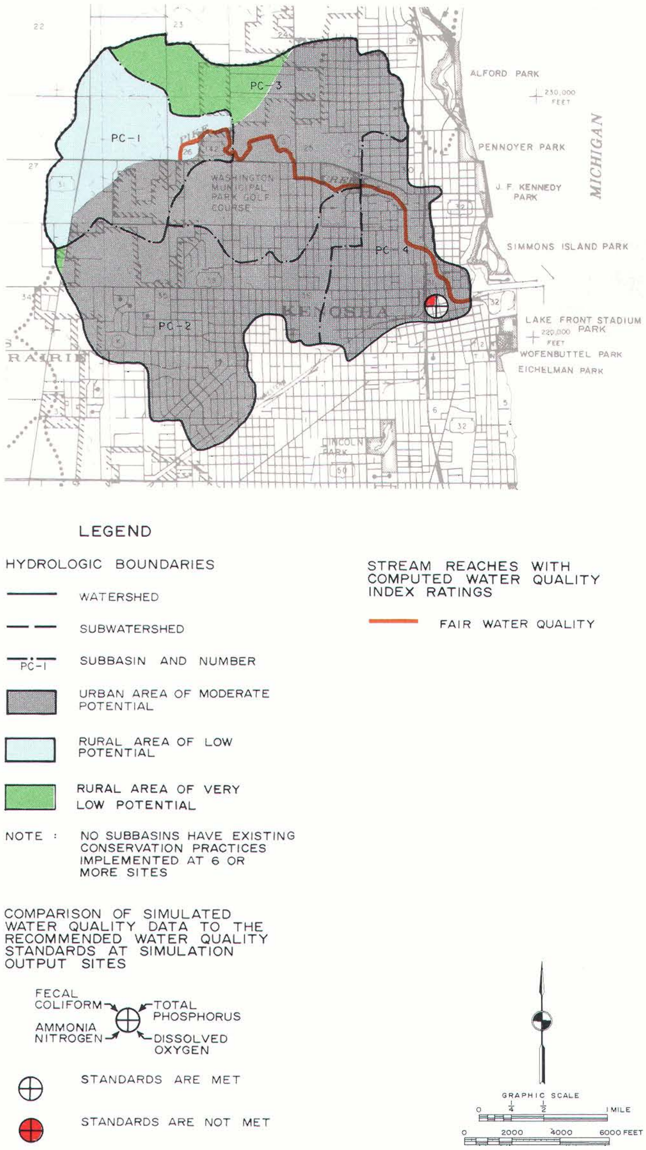
Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Pike Creek subwatershed. No known major livestock operations exist in the subwatershed.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $1,169,000 essentially all being for urban practices, and an average annual operation and maintenance cost of $38,000, of which $36,000, or 95 percent, would be for urban practices and $2,000, or 5 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 59.

Sucker Creek Subwatershed: The water quality of Sucker Creek was simulated for eight stream reaches and their associated subbasins, with the results reported and statistically analyzed for one simulation site, as shown on Map 19, under existing conditions and under plan year 2000 conditions. The simulation site is located at the confluence of Sucker Creek with Lake Michigan. Figure 87 presents the percent of time the applicable water quality standards are satisfied under existing land use conditions as well as under year 2000 land use conditions. Sucker Creek is classified for warmwater fishery and aquatic life and recreational use. As shown in

## Map 18

### DIFFUSE SOURCE POLLUTION POTENTIAL IN THE PIKE CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED




The hydrologic subbasins in the Pike Creek subwatershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 3,586 acres devoted to urban land uses in the subwatershed, all recorded a moderate potential rating for nonpoint source pollution. The approximately 958 acres devoted to rural land uses in the subwatershed were all estimated to have a low or very low potential for nonpoint source pollution. Thus, as of 1975, the Pike Creek subwatershed exhibited a moderate potential for urban nonpoint source pollution and a low potential for rural nonpoint source pollution.

*Source: SEWRPC.*

## Table 59

### ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE PIKE CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] | $ | $ |
| Low-Cost Urban Diffuse Source Controls[b] | Minimal | 31,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures | 468,000 | Minimal |
| Construction Erosion Control Practices | 701,000 | 5,000 |
| Subtotal | $1,169,000 | $36,000 |
| Rural | | |
| Minimum Conservation Practices[c] | Minimal | 2,000 |
| Total | $1,169,000 | $38,000 |

[a] *The proper maintenance of the remaining septic tank systems until the provision of sanitary sewer service is recommended to help improve the water quality of the Pike Creek subwatershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include an average annual operation and maintenance cost prior to the provision of sanitary sewer service of $7,000.*

[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, contour plowing, fertilizer and pesticide management, and critical area protection.*

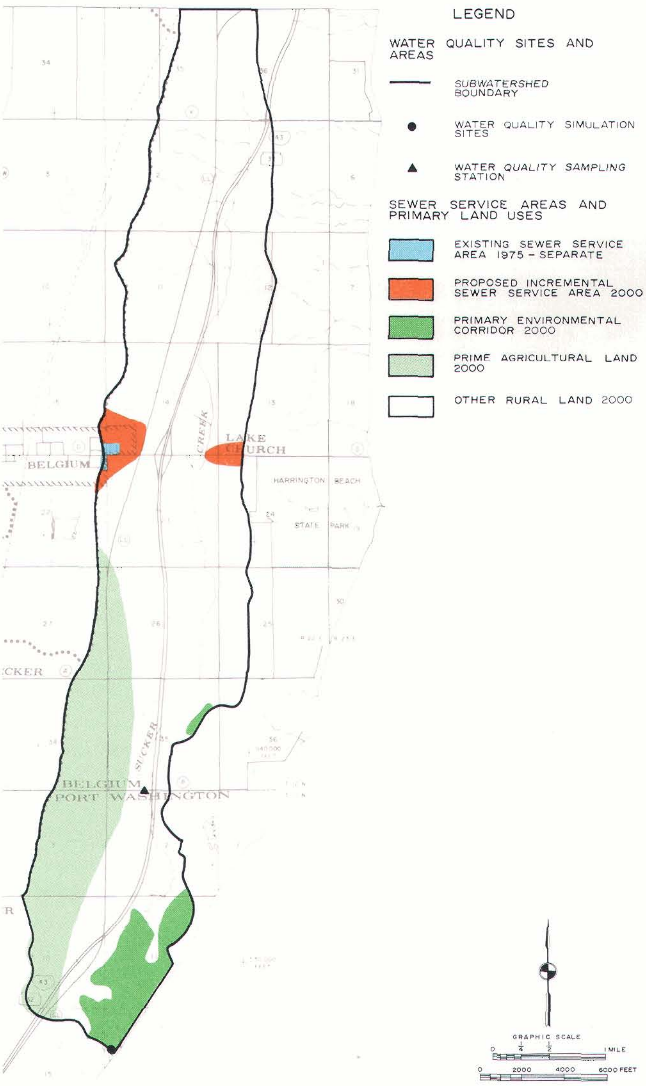
*Source: SEWRPC.*

Table 60, the recommended water quality standards for temperature, dissolved oxygen, fecal coliform, un-ionized ammonia-nitrogen, and phosphorus are met under both existing and year 2000 planned land use conditions without diffuse source controls when interpreted against the allowable levels of water quality achievement.

Because calibration data were not available for Sucker Creek, such data from the adjacent Sauk Creek were used. While the above simulation results indicate that only a minimum reduction in diffuse source loads is required, analyses presented in SEWRPC Technical Report No. 17, Water Quality of Lakes and Streams in Southeastern Wisconsin: 1964-1975 indicated that in Sucker Creek during low-flow summer periods from 1964-1975, the dissolved oxygen standard was violated in 30 percent of the samples, the phosphorus standard was violated in all of the samples, and the fecal coliform standard was violated in 32 percent of the samples. SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975 evaluated the sources of pollution within each watershed and these evaluations

Map 19

WATER QUALITY SIMULATION SITE IN THE SUCKER CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED




The Sucker Creek subwatershed has an area of about 10 square miles. Within the Sucker Creek subwatershed there are eight identified hydrologic subbasins and one water quality simulation output site. Also located within the subwatershed is one site for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were no known point sources of water pollution in the subwatershed to be considered in the water quality analyses. The subwatershed is expected to undergo only slight urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 5 and 8 percent of the total subwatershed area, respectively.

*Source: SEWRPC.*

indicated that the Sucker Creek subwatershed has a high concentration of livestock operations. It is therefore likely that diffuse source loads—especially from livestock operations—are indeed excessive in the subwatershed.

Table 60

REQUIRED DIFFUSE SOURCE CONTROL LEVELS IN THE SUCKER CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

| Load Reduction Required | | | |
|---|---|---|---|
| Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| Minimum | Minimum | Minimum | Minimum |

*Source: SEWRPC.*

*Identification of Pollution Priority Problem Areas:* The hydrologic subbasins in the Sucker Creek subwatershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 20 indicates the areal extent of the various levels of diffuse source pollution potential in the subwatershed, and Table 61 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

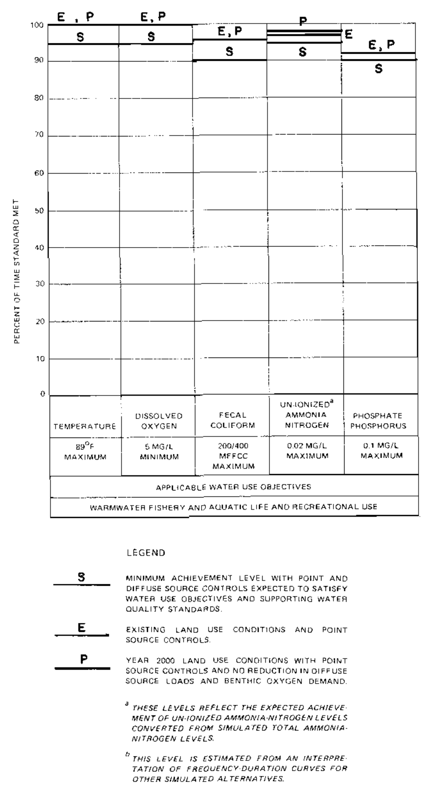
The pollution potential classification analysis for the Sucker Creek subwatershed indicated a moderate rating in urban pollution potential for that portion of the Village of Belgium within the subwatershed. Less than 15 percent of the rural area is designated by a high pollution potential rating, with more than 85 percent of the area being classified as having a low or moderate potential rating.

*Control of Pollutant Runoff from Urban Land:* Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Sucker Creek subwatershed. Industrial and commercial material storage facilities and runoff control measures are anticipated to be needed in the Sucker Creek subwatershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution.

*Control of Pollutant Runoff from Rural Land:* Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of Sucker Creek. As previously

Figure 87

**EXPECTED WATER QUALITY STANDARD ACHIEVEMENT IN THE SUCKER CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL**




stated, animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding facilities, are extremely important to sufficiently reduce pollutant loadings. In addition, those animal operations located less than 500 feet from a stream and in high or very high pollution potential areas (see Map 20), may require manure storage through the winter in a dry stacking system incorporating runoff control or in a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff.

Table 61

**AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE SUCKER CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHGIAN WATERSHED: 1975**

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Subwatershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Subwatershed Area |
| Very High . . | -- | -- | -- | -- | -- | -- |
| High . . . . . | -- | -- | 916 | 14 | 916 | 14 |
| Moderate. . . | 110 | 100 | 1,964 | 30 | 2,074 | 31 |
| Low. . . . . . | -- | -- | 3,666 | 56 | 3,666 | 55 |
| Very Low . . | -- | -- | -- | -- | -- | -- |
| Total | 110 | 100 | 6,546 | 100 | 6,656 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

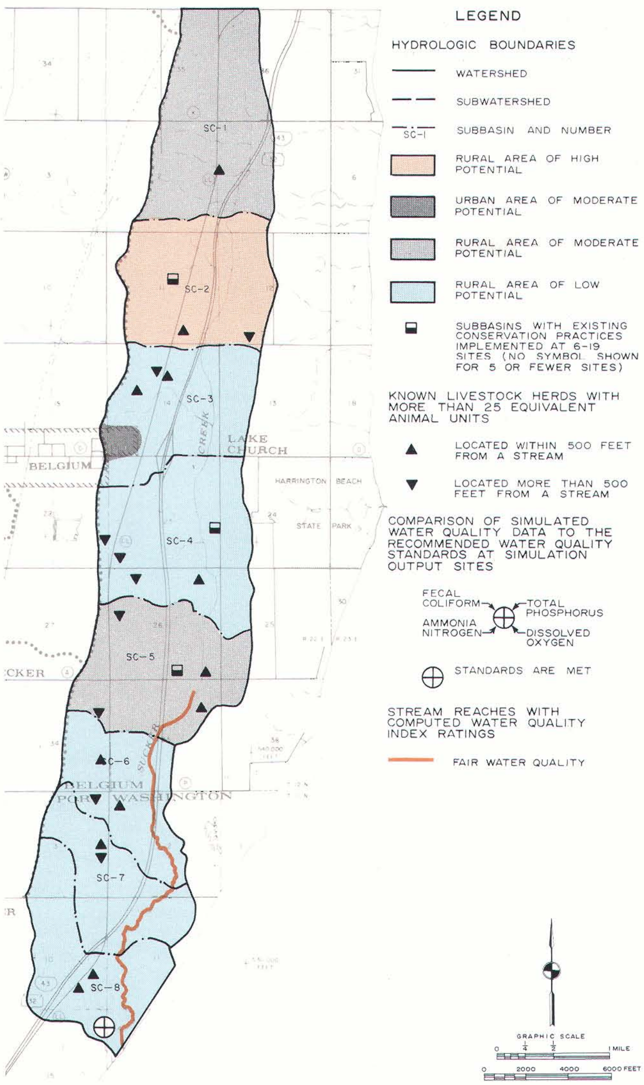
*Source: SEWRPC.*

*Cost Estimate:* Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $614,000, of which $272,000, or 44 percent, would be for urban practices and $342,000, or 56 percent, would be for rural practices, and an average annual operation and maintenance cost of $36,000, of which $3,000, or 8 percent, would be for urban practices and $33,000, or 92 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 62.

Direct Tributary Area to Lake Michigan: For the minor perennial streams directly tributary to Lake Michigan within the Region—Barnes Creek, Pike Creek, and Sucker Creek—existing and forecast water quality was simulated under the areawide water quality management planning program. Based upon the results for these areas and the similarities in land uses and drainage patterns, diffuse source control measures are recommended for the balance of the Lake Michigan direct tributary area to provide proper land management, prevent further degradation of the existing quality of these streams, eliminate localized severe water quality problems, and protect the Lake Michigan near-shore waters. These water quality control measures should be reconsidered in the development of a comprehensive plan for the area of direct drainage to Lake Michigan, and in local implementation plans. Estimated costs for the measures are included in the areawide water quality management plan. These measures must not be misconstrued, however, as the solution to the bluff erosion problem along the lakeshore. This far more serious problem will require a major engineering study and may require expensive public works to resolve. This topic is addressed in more detail

Map 20

DIFFUSE SOURCE POLLUTION POTENTIAL IN THE SUCKER CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED




The hydrologic subbasins in the Sucker Creek subwatershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. All of the approximately 110 acres devoted to urban land uses in the subwatershed recorded a moderate potential rating for nonpoint source pollution. Of the 6,546 acres devoted to rural land uses in the subwatershed, 14 percent was estimated to have a high pollution potential, 30 percent a moderate potential, and 56 percent a low potential for rural nonpoint source pollution. Thus, as of 1975, the Sucker Creek subwatershed exhibited a moderate potential for urban nonpoint source pollution and a moderate to low potential for rural nonpoint source pollution.

*Source: SEWRPC.*

in the SEWRPC Prospectus, Lake Michigan Estuary and Direct Drainage Area Subwatersheds Planning Program Prospectus.

Table 62

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE SUCKER CREEK SUBWATERSHED OF THE MINOR STREAMS TRIBUTARY TO LAKE MICHIGAN WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost | |
|---|---|---|
| | Total Capital (1975-2000) | Average Annual Operation and Maintenance |
| **Urban** | | |
| Septic System Management[a] . . . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . . . . . . . . . . . . . | Minimal | 1,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . . . . . . | 3,000 | Minimal |
| Construction Erosion Control Practices . . | 269,000 | 2,000 |
| Subtotal | $272,000 | $ 3,000 |
| **Rural** | | |
| Minimum Conservation Practices[c] . . . . . | 2,000 | 12,000 |
| Livestock Waste Control . . . . . . . . . . | 340,000 | 21,000 |
| Subtotal | $342,000 | $33,000 |
| Total | $614,000 | $36,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of Sucker Creek. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $23,000, and an average annual operation and maintenance cost of $5,000.*

[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

*Control of Pollutant Runoff from Urban Land:* Minimum and low-cost urban diffuse source pollution control practices alone—such as public education program; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—may be expected to provide a sufficient level of urban diffuse source pollution control in the Lake Michigan direct drainage area. Construction erosion control practices and proper management of onsite sewage treatment systems should also be used to abate diffuse source pollution.

*Control of Pollutant Runoff from Rural Land:* Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the direct drainage area. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding facilities, are needed to sufficiently reduce pollutant loadings from all animal operations.

*Cost Estimate:* Costs for livestock waste control and septic tank system management within the Lake Michigan direct tributary drainage area were estimated from costs calculated for the adjoining Barnes Creek, Pike Creek, and Sucker Creek subwatersheds. This estimate assumes that the livestock and septic tank system densities in the direct drainage area approximate the densities inventoried for the subwatersheds' three perennial streams. Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $4.7 million, of which $4.3 million, or 92 percent, would be for urban practices and $376,000, or 8 percent, would be for rural practices, and an average annual operation and maintenance cost of $65,000, of which $25,000, or 38 percent, would be for urban practices and $40,000, or 62 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 63.

Table 63

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE LAKE MICHIGAN DIRECT TRIBUTARY DRAINAGE AREA

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] | $ -- | $ -- |
| Low-Cost Urban Land Management Practices[b] | Minimal | 4,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures | 1,410,000 | Minimal |
| Construction Erosion Control Practices | 2,883,000 | 21,000 |
| Subtotal | 4,293,000 | $ 25,000 |
| Rural | | |
| Minimum Conservation Practices[c] | 2,000 | 14,000 |
| Livestock Waste Control | 374,000 | 26,000 |
| Subtotal | $ 376,000 | $ 40,000 |
| Total | $4,669,000 | $65,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of the Lake Michigan direct drainage area. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $86,000, and an average annual operation and maintenance cost of $86,000.*

[b] *Low-cost urban practices include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

Oak Creek Watershed

The water quality of Oak Creek and its major tributaries was simulated for 23 stream reaches and their associated subbasins, with the results reported and statistically analyzed for eight simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The location of these eight simulation sites and the corresponding tributary water quality analysis areas are shown on Map 21 and presented in Table 64. The following discussion and Figures 88 through 95 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions with point source controls only, and with point source controls coupled with a 50 or 75 percent reduction in diffuse source pollutant loadings. The streams in the Oak Creek watershed are classified for warmwater fishery and aquatic life and recreational use.

Table 64

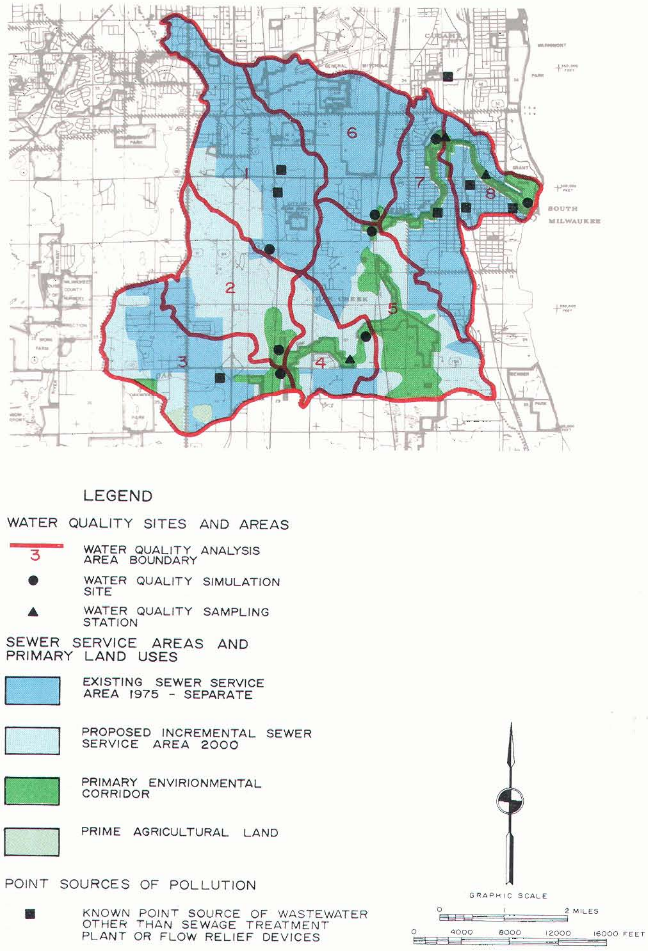
LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE OAK CREEK WATERSHED

| Water Quality Analysis Areas as Presented on Map 21 | Location of Most Downstream Point Draining the Water Quality Analysis Area: Location | Location of Most Downstream Point Draining the Water Quality Analysis Area: U. S. Public Land Survey Designation |
|---|---|---|
| | North Branch of Oak Creek | |
| 1 | Downstream from Drexel Avenue | T5N, R22E, Section 17 |
| 2 | Upstream of confluence with Oak Creek main stem | T5N, R22E, Section 20 |
| | Oak Creek | |
| 3 | Upstream of confluence with North Branch | T5N, R22E, Section 20 |
| 4 | At Chicago North Shore & Milwaukee Railroad | T5N, R22E, Section 21 |
| 5 | At Chicago & North Western Railway | T5N, R22E, Section 9 |
| 7 | At 15th Avenue | T5N, R22E, Section 3 |
| 8 | At confluence with Lake Michigan | T5N, R22E, Section 12 |
| | Mitchell Field drainage ditch | |
| 6 | Upstream of confluence with Oak Creek main stem | T5N, R22E, Section 9 |

*Source: SEWRPC.*

Map 21

## WATER QUALITY ANALYSIS AREAS IN THE OAK CREEK WATERSHED




The Oak Creek watershed has an area of about 26 square miles and ranks tenth in size and eighth in total resident population of the 12 watersheds in the Region. Within the Oak Creek watershed there are 23 identified hydrologic subbasins grouped into eight water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are three sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 10 point sources of water pollution—including two sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo substantial urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 44 and 68 percent of the total watershed area, respectively.

*Source: SEWRPC.*

Temperature: It is apparent from Figures 88 through 95 that the temperature standard of 89°F is satisfied within the Oak Creek watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: A reduction in diffuse source pollution is not necessary for the water quality analysis areas in the Oak Creek watershed to satisfy the warmwater fishery and aquatic life dissolved oxygen standard of 5 milligrams per liter (mg/l).

Fecal Coliform: The water quality simulation data indicate that no water quality analysis area within the Oak Creek watershed will satisfy a fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml). Furthermore, all analysis areas exceed a level of 1,000 MFFCC/100 ml at least 10 percent of the time even under a diffuse source loading reduction of 75 percent. These violations are attributed to fecal coliform loadings to Oak Creek from high numbers of septic tank systems, many of which are malfunctioning, located on unsuitable soil, and densely situated on small lots. The water quality effects of abating such improperly operating septic tank systems are not reflected in the land surface fecal coliform loadings estimated for year 2000 land use conditions, at which time the entire watershed is expected to be served by sanitary sewers. In addition, it is possible that unknown sewage flow relief devices exist within the Oak Creek watershed, thus exaggerating land surface loadings. Accordingly, it is estimated that the elimination of septic tank systems and the identification and control of possible sewage flow relief devices—in combination with an additional 50 percent reduction of the remaining fecal coliform load associated with storm water runoff—would result in a total fecal coliform load reduction of nearly 90 percent. It is recommended that a high level of pollution control measures effective in reducing fecal coliform levels be implemented, and that local implementation efforts review the existing and future sources of fecal coliform to Oak Creek and the effectiveness of the actions taken to abate this pollution.

Un-ionized Ammonia-Nitrogen: Water quality analysis areas 1, 2, and 3 are expected to satisfy an un-ionized ammonia-nitrogen standard of 0.02 mg/l under year 2000 land use conditions with recommended point source controls and a 50 percent reduction in diffuse source loads. Analysis areas 4 and 5 will require an approximate 75 percent reduction in diffuse source loads, and areas 6, 7, and 8 will require in excess of a 75 percent reduction in diffuse source loads to satisfy the applicable standard. The primary source of these excessive un-ionized ammonia-nitrogen levels is assumed to be malfunctioning septic tank systems. As with fecal coliform, the elimination of these septic tank systems—in combination with a 50 percent reduction in storm water runoff loads—is expected to achieve the desired level of un-ionized ammonia-nitrogen.

Phosphate-Phosphorus: A 75 percent reduction in diffuse source loadings is estimated to be required for all water quality analysis areas in the Oak Creek watershed to satisfy a phosphorus standard of 0.1 mg/l under year 2000 land use conditions. The elimination of septic tank systems and a 50 percent reduction in storm water runoff loads will again be necessary to achieve this standard.

## Figures 88-95

## EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE OAK CREEK WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 88

WATER QUALITY ANALYSIS AREA 1

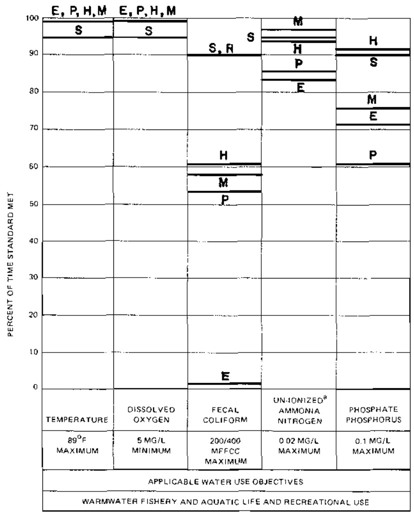



Figure 89

WATER QUALITY ANALYSIS AREA 2

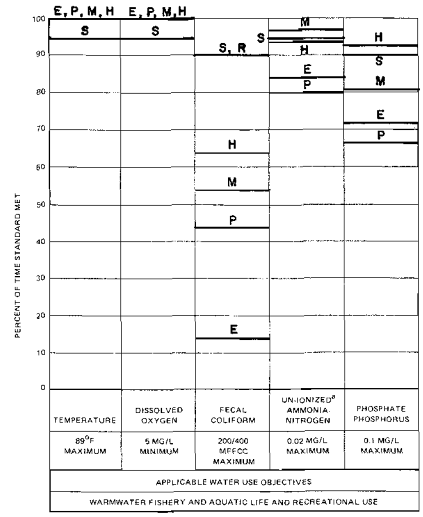



Figure 90

WATER QUALITY ANALYSIS AREA 3

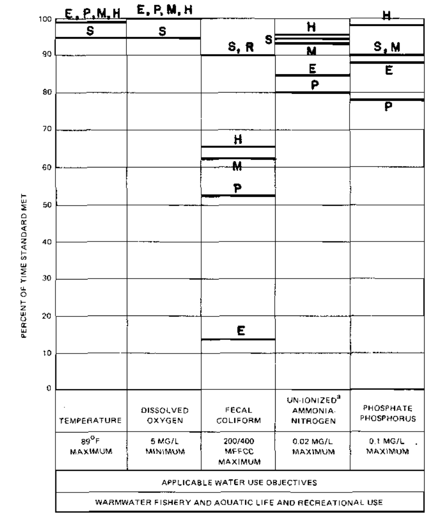



Figure 91

WATER QUALITY ANALYSIS AREA 4

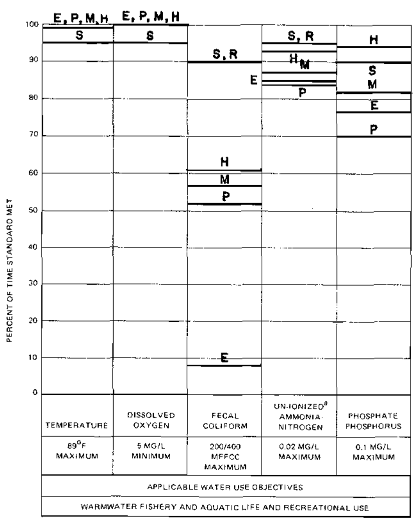



Figure 92

WATER QUALITY ANALYSIS AREA 5

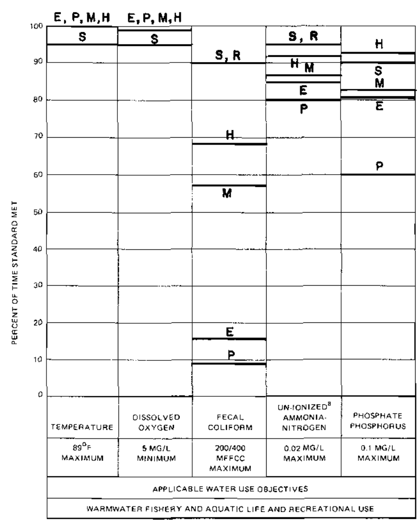



Figure 93

WATER QUALITY ANALYSIS AREA 6

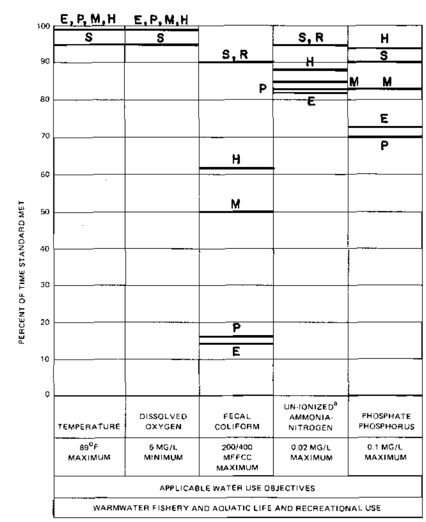



Figure 94

WATER QUALITY ANALYSIS AREA 7

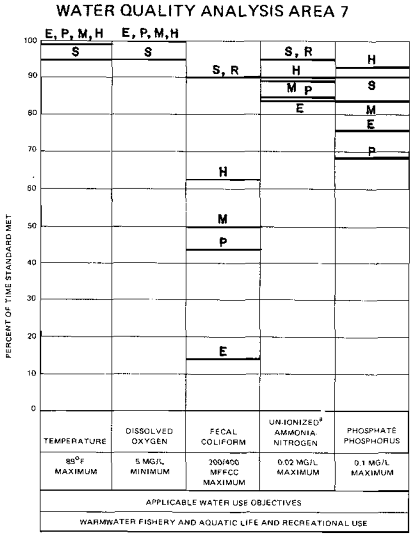
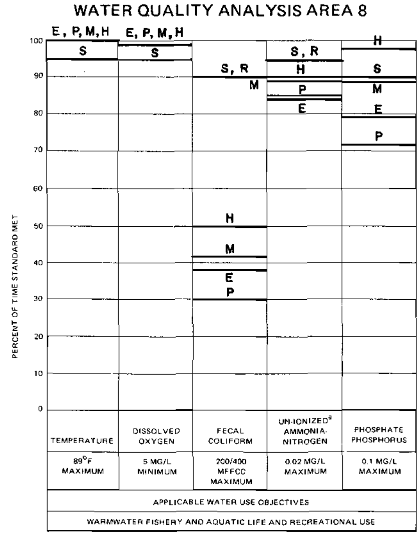



Figure 95

WATER QUALITY ANALYSIS AREA 8




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

H — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A HIGH (75%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

*Source: SEWRPC.*

Summary: Table 65 presents the general level of diffuse source pollutant loading reductions necessary to satisfy the applicable water quality standards for the Oak Creek watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended. In general, at least a 50 percent reduction in diffuse source pollutant loadings—in addition to the elimination of septic tank systems through the provision of sanitary sewer service—is required in the Oak Creek watershed.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Oak Creek watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 22 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 66 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

The pollution potential classification analysis for the Oak Creek watershed indicated relatively little variation in urban pollution potential, with almost all analyzed urban years receiving a low or moderate rating. The portions of the City of South Milwaukee and General Mitchell Field within the watershed received a moderate urban pollution potential rating, with most other urban areas receiving a low pollution potential rating. The rural classification indicates that half of the watershed has a low rural pollution rating and half has a very low rating.

Control of Pollutant Runoff from Urban Land: Mininum and low-cost urban diffuse source pollution control practices—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control

Table 65

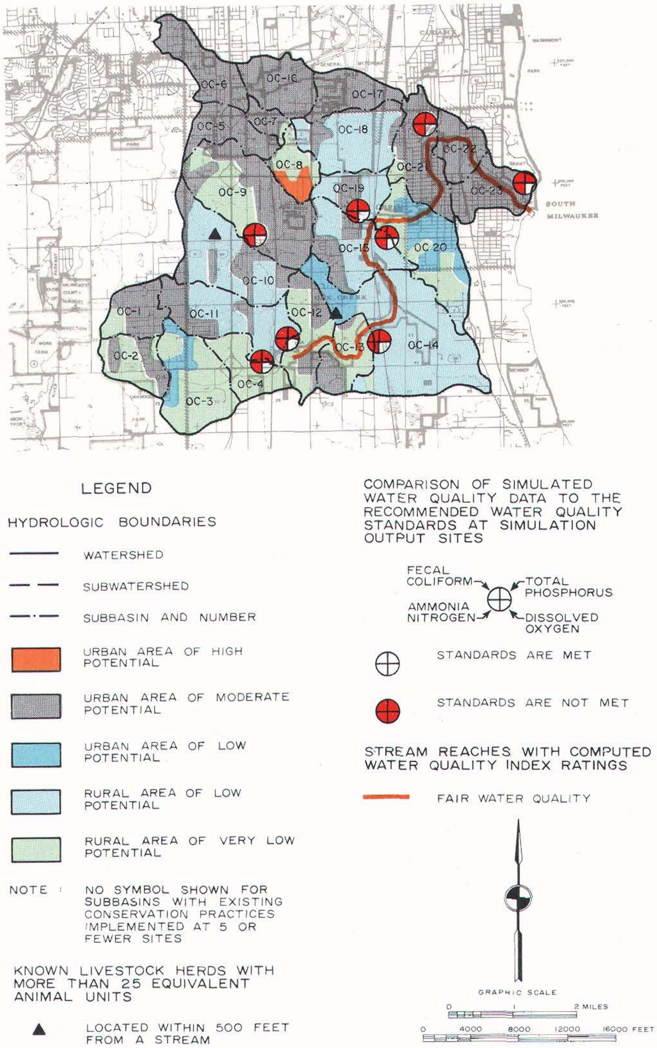
**REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE OAK CREEK WATERSHED**

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum | More than 75 | 50 | 75 |
| 2 | Minimum | More than 75 | 50 | 75 |
| 3 | Minimum | More than 75 | 50 | 75 |
| 4 | Minimum | More than 75 | 75 | 75 |
| 5 | Minimum | More than 75 | 75 | 75 |
| 6 | Minimum | More than 75 | More than 75 | 75 |
| 7 | Minimum | More than 75 | More than 75 | 75 |
| 8 | Minimum | More than 75 | More than 75 | 75 |

*Source: SEWRPC.*

Map 22

**DIFFUSE SOURCE POLLUTION POTENTIAL IN THE OAK CREEK WATERSHED**




The hydrologic subbasins in the Oak Creek watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Most of the 7,143 acres devoted to urban land uses in the watershed recorded a moderate potential rating for nonpoint source pollution. All of the 9,708 acres devoted to rural land uses in the watershed were estimated to have a low or very low potential for nonpoint source pollution. Thus, as of 1975, the Oak Creek watershed exhibited a moderate potential for urban nonpoint source pollution and a low potential for rural nonpoint source pollution.

*Source: SEWRPC.*

measures; and critical area protection—should be implemented for diffuse source pollution control in the watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution. These low-cost urban practices alone are not anticipated to provide a sufficient level of urban diffuse

Table 66

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE OAK CREEK WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | -- | -- | -- | -- | -- | -- |
| High . . . . . | -- | -- | -- | -- | -- | -- |
| Moderate. . . | 5,930 | 83 | -- | -- | 5,930 | 35 |
| Low. . . . . . | 1,148 | 16 | 4,855 | 50 | 6,003 | 36 |
| Very Low . . | 65 | 1 | 4,853 | 50 | 4,918 | 29 |
| Total | 7,143 | 100 | 9,708 | 100 | 16,851 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

Table 67

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE OAK CREEK WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost | |
|---|---|---|
| | Total Capital (1975-2000) | Average Annual Operation and Maintenance |
| Urban | | |
| Septic System Management[a] . . . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . . . . . . . . . . . . . | Minimal | 41,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . . . . . . | 1,110,000 | Minimal |
| Additional Urban Diffuse Source Controls[c] . . . . . . . . . . . . . . | 519,000 | 420,000 |
| Construction Erosion Control Practices . . | 7,763,000 | 56,000 |
| Subtotal | $9,392,000 | $517,000 |
| Rural | | |
| Minimum Conservation Practices[d] . . . . . | 3,000 | 12,000 |
| Additional Conservation Practices[e] . . . . | 163,000 | 12,000 |
| Livestock Waste Control . . . . . . . . . . | 10,000 | 1,000 |
| Subtotal | $ 176,000 | $ 25,000 |
| Total | $9,568,000 | $542,000 |

[a] *The proper maintenance of the remaining septic tank systems in the interim period prior to the provision of sanitary sewer service is recommended to help improve the water quality of Oak Creek. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include an annual operation and maintenance cost of $3,000.*

[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Additional urban diffuse source control practices necessary to achieve a 50 percent reduction in urban land diffuse source loads include increased street sweeping, increased leaf and vegetable debris collection and disposal, streambank protection measures, increased catch basin cleaning, and improved street maintenance and refuse collection.*

[d] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

[e] *Additional conservation practices necessary to achieve a 50 percent reduction in rural land diffuse source loads include crop rotation, contour strip-cropping, grass waterways, diversions, wind erosion controls, terraces, stream protection measures, and vegetative buffer strips.*

*Source: SEWRPC.*

source pollution control in the Oak Creek watershed. Many other measures will need to be instituted, including improved street sweeping practices, with improved vacuum sweepers, increased sweeping frequencies, and the enactment of supporting parking ordinances; streambank protection measures; improved street maintenance and refuse collection and disposal; improved and more frequent leaf collection with vacuum sweepers; and increased catch basin cleaning in existing areas with vacuum cleaners.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Oak Creek watershed. In addition, control measures should be developed to prevent excessive pollutant contributions from livestock operations. Additional conservation practices, such as crop rotation, contour strip-cropping, grassed waterways, diversions, streambank protection measures, vegetative buffer strips along streams, wind erosion controls, and terraces, should also be effected for water quality enhancement purposes and for the prevention of soil erosion.

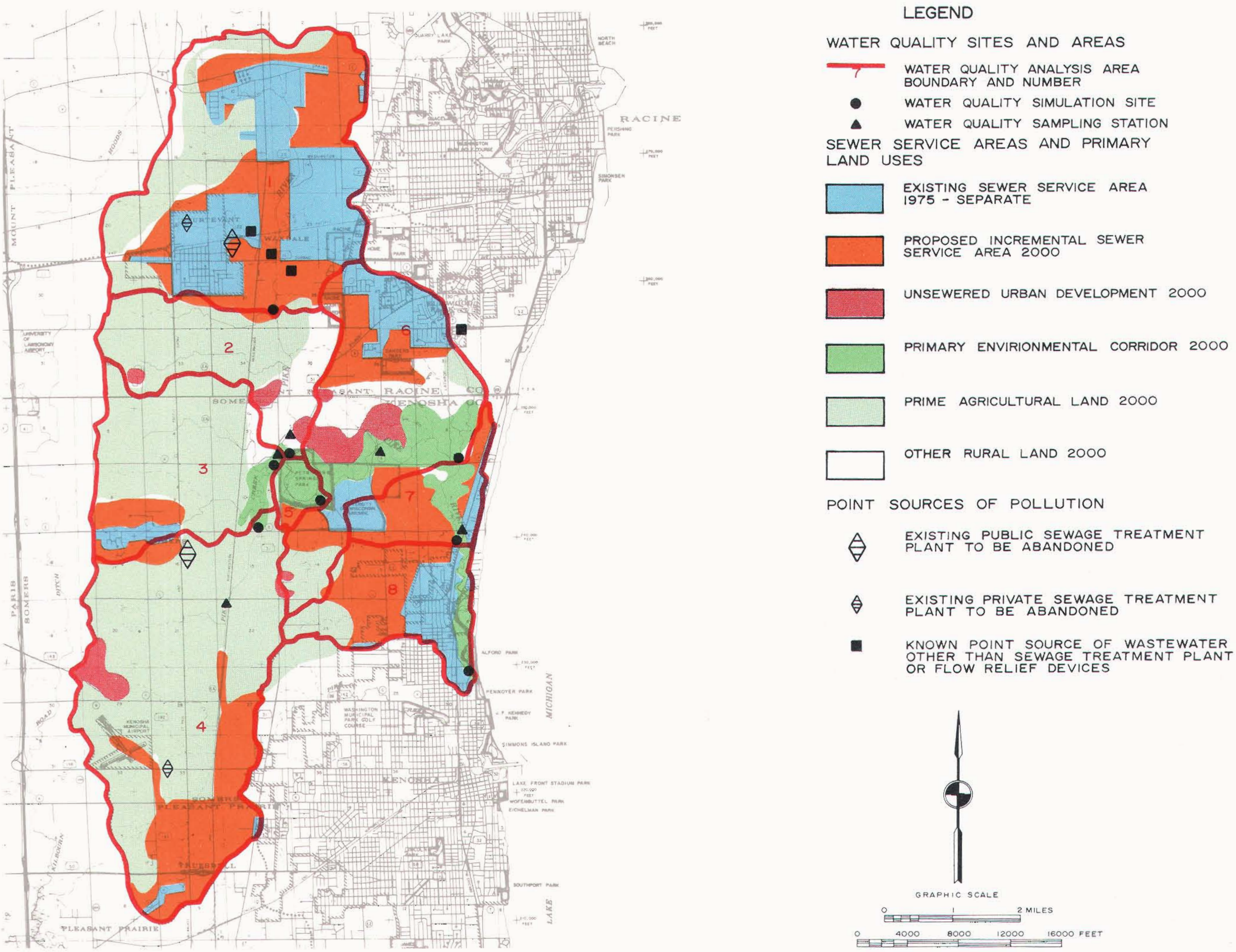
Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $9.6 million, of which $9.4 million, or 98 percent, would be for urban practices and $176,000, or 2 percent, would be for rural practices, and an average annual operation and maintenance cost of $542,000, of which $517,000, or 95 percent, would be for urban practices and $25,000, or 5 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 67.

Pike River Watershed

The water quality of the Pike River and its major tributaries was simulated for 46 stream reaches and their associated subbasins, with the results reported and statistically analyzed for eight simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The location of these eight simulation sites and the corresponding tributary water quality analysis areas are shown on Map 23 and presented in Table 68. The following discussion and Figures 96 through 103 present the percent of

## Map 23

### WATER QUALITY ANALYSIS AREAS IN THE PIKE RIVER WATERSHED




The Pike River watershed has an area of 51 square miles and ranks eighth in size and ninth in total resident population of the 12 watersheds in the Region. Within the Pike River watershed there are 46 identified hydrologic subbasins grouped into eight water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are six sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 16 point sources of water pollution—including eight sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo significant urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 23 and 34 percent of the total watershed area, respectively.

*Source: SEWRPC.*

time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions with point source controls only, and with point source controls coupled with a 25 or 50 percent reduction in diffuse source pollutant loadings. The streams in the Pike River watershed are classified for warmwater fish and aquatic life and recreational use.

Temperature: It is apparent from Figures 96 through 103 that the temperature standard of 89°F is satisfied within the Pike River watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: In general, only minimum diffuse source controls will be necessary to satisfy the warmwater fishery and aquatic life dissolved oxygen standard

Table 68

LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE PIKE RIVER WATERSHED

| Water Quality Analysis Area as Presented on Map 23 | Location of Most Downstream Point Draining the Water Quality Analysis Area | |
|---|---|---|
| | Location | U. S. Public Land Survey Designation |
| | Pike River | |
| 1 | Town of Mt. Pleasant, east of Chicago & North Western right-of-way | T3N, R22E, Section 27 |
| 2 | Town of Somers, east of STH 31 | T2N, R22E, Section 2 |
| 5 | Town of Somers, north of CTH JR | T2N, R22E, Section 11 |
| 6 | Town of Somers, north of CTH A | T2N, R23E, Section 7 |
| 7 | Town of Somers, west of Chicago & North Western right-of-way | T2N, R23 E, Section 18 |
| 8 | Town of Somers, at confluence with Lake Michigan | T2N, R23E, Section 19 |
| | Pike Creek | |
| 3 | Town of Somers, south of CTH A | T2N, R22E, Section 3 |
| 4 | Town of Somers, north of CTH E | T2N, R22E, Section 10 |

*Source: SEWRPC.*

of 5 milligrams per liter (mg/l) within the Pike River watershed. However, slight dissolved oxygen problems are indicated in water quality analysis areas 1 and 2, which are drained by the Pike River upstream of the confluence with Pike Creek. These problems are caused by high oxygen demand from bottom deposits and benthic organisms, and are estimated to be primarily attributable to historical and existing contributions from both point and diffuse sources. Upon the control of these point sources and the implementation of minimum diffuse source controls under plan year 2000 conditions, it is likely that these bottom deposits will either stabilize or be assimilated by the stream system. If, following the implementation of pollution control measures, the benthic oxygen demand is not sufficiently reduced, the possibility of channel dredging activities should be investigated to facilitate the stabilization of some severe areas. A 25 percent reduction in the oxygen demand from the bottom deposits will achieve the desired level of dissolved oxygen. Under 2000 planned land use conditions, no other analysis areas violate the dissolved oxygen standard except area 6, which is expected to satisfy the applicable standard upon the implementation of minimum diffuse source controls.

Fecal Coliform: Water quality analysis areas 1 and 8 will not require a reduction in diffuse source loadings to satisfy the recreational use fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml) under year 2000 planned land use conditions with recommended point source controls. Analysis area 5 is expected to require a 50 percent reduction in diffuse source fecal coliform loads, and areas 2, 3, 4, 6, and 7 will require in excess of a 50 percent reduction to satisfy the fecal coliform standard.

Phosphate-Phosphorus: Under year 2000 planned land use conditions with recommended point source controls, the phosphorus standard of 0.1 mg/l is satisfied by all water quality analysis areas without diffuse source pollutant loading reductions.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Pike River watershed indicate that the level of 0.02 mg/l is seldom exceeded. Diffuse source controls will not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Summary: Table 69 presents the general level of diffuse source pollutant loading reductions necessary to satisfy the applicable water quality standards for the Pike River watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Pike River watershed were classified according to selected criteria which indicate the existing potential of an area to contribute diffuse source pollutants to surface waters. Map 24 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 70 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

Table 69

REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE PIKE RIVER WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum[a] | Minimum | Minimum | Minimum |
| 2 | Minimum[a] | More than 50 | Minimum | Minimum |
| 3 | Minimum | More than 50 | Minimum | Minimum |
| 4 | Minimum | More than 50 | Minimum | Minimum |
| 5 | Minimum | 50 | Minimum | Minimum |
| 6 | Minimum | More than 50 | Minimum | Minimum |
| 7 | Minimum | More than 50 | Minimum | Minimum |
| 8 | Minimum | Minimum | Minimum | Minimum |

[a] *Requires reduction in benthic oxygen demand, which is expected to result if point source and minimum diffuse source controls are implemented.*

*Source: SEWRPC.*

## Figures 96-103

# EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE PIKE RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 96

WATER QUALITY ANALYSIS AREA 1

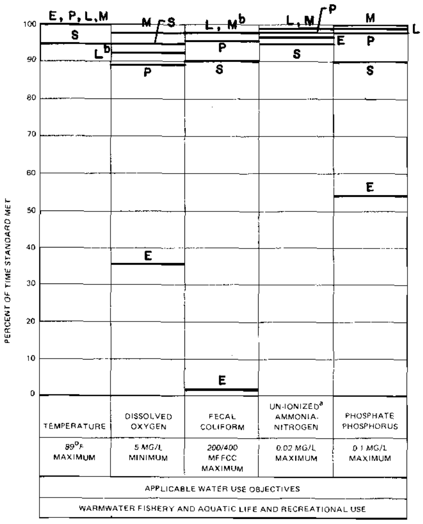



Figure 97

WATER QUALITY ANALYSIS AREA 2

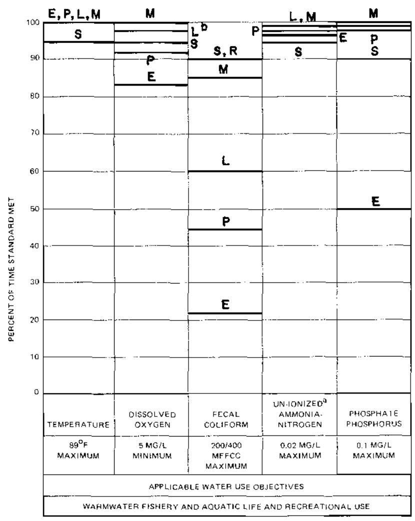



Figure 98

WATER QUALITY ANALYSIS AREA 3

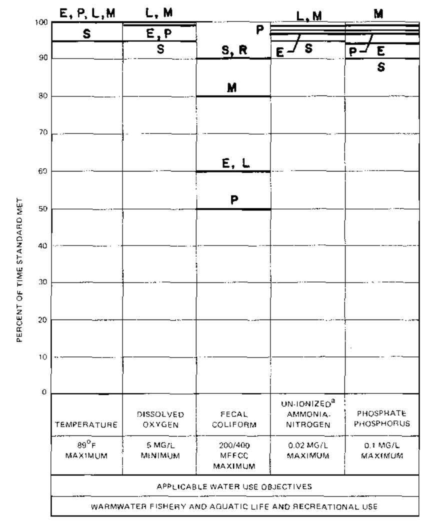



Figure 99

WATER QUALITY ANALYSIS AREA 4

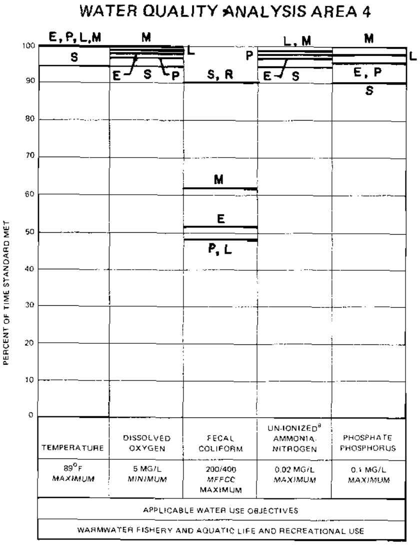



Figure 100

WATER QUALITY ANALYSIS AREA 5

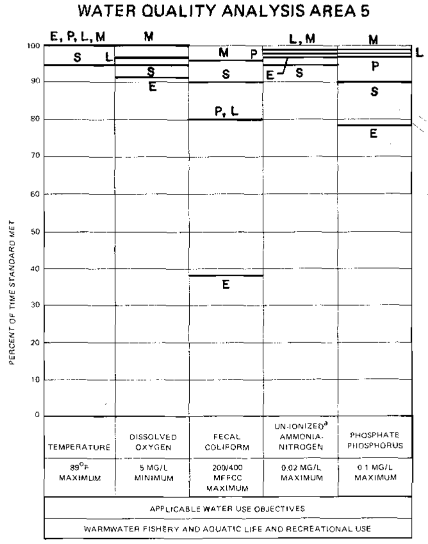



Figure 101

WATER QUALITY ANALYSIS AREA 6

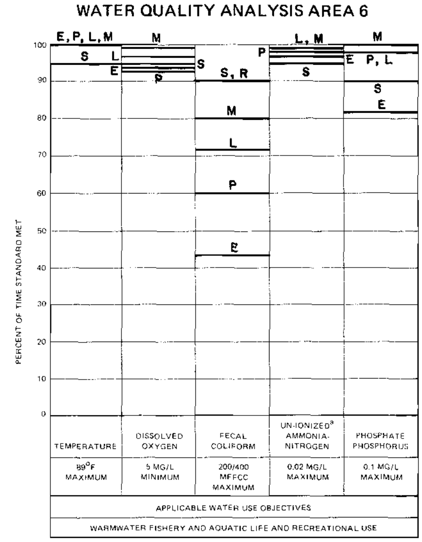



Figure 102

WATER QUALITY ANALYSIS AREA 7

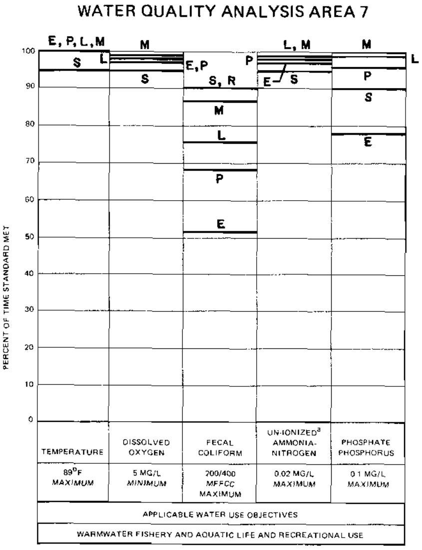
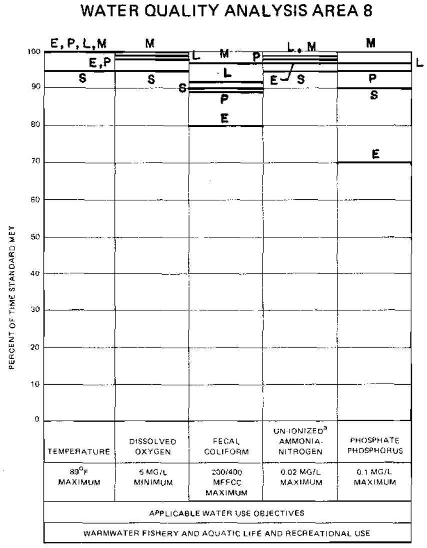



Figure 103

WATER QUALITY ANALYSIS AREA 8




LEGEND

- S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.
- E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.
- P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.
- L — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A LOW (25%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.
- M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.
- R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

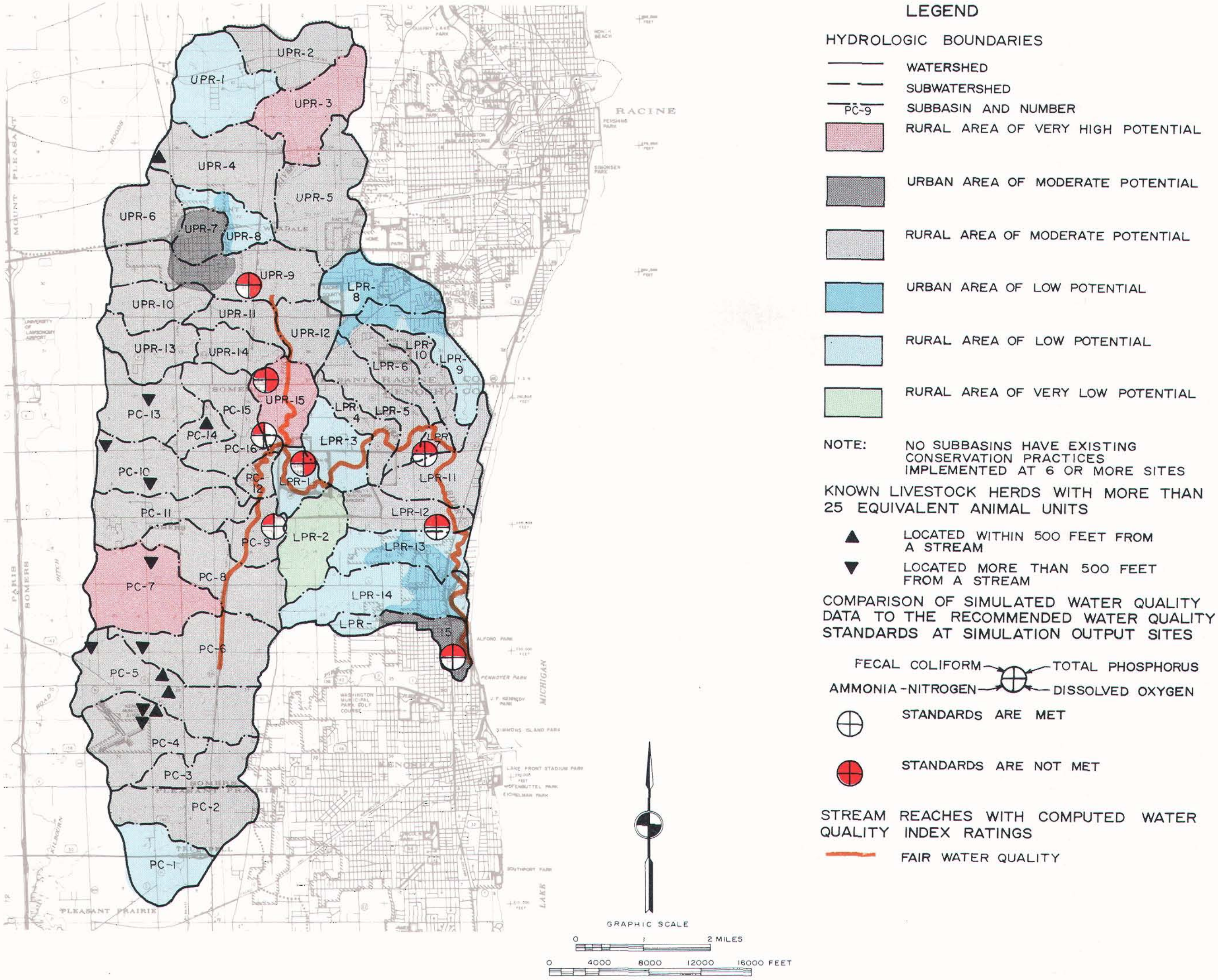
[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

*Source: SEWRPC.*

Map 24

DIFFUSE SOURCE POLLUTION POTENTIAL IN THE PIKE RIVER WATERSHED




The hydrologic subbasins in the Pike River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 1,208 acres devoted to urban land uses in the watershed, 39 percent recorded a moderate potential rating and 61 percent a low potential rating for nonpoint source pollution. Of the 31,214 acres devoted to rural land uses in the watershed, 9 percent was estimated to have a very high potential, 71 percent a moderate potential, and the remaining 20 percent a low or very low potential for rural nonpoint source pollution. Thus, as of 1975, the Pike River watershed exhibited a low to moderate potential for urban nonpoint source pollution and a moderate potential for rural nonpoint source pollution, although some rural areas with severe pollution potential exist.

*Source: SEWRPC.*

The pollution potential classification analysis for the Pike River watershed indicated relatively little variation in urban pollution potential, with all analyzed urban areas receiving a low or moderate rating. The portion of the Village of Elmwood Park and the northernmost portion of the City of Kenosha within the watershed received low urban potential ratings, whereas the Village of Sturtevant and the remaining portion of the City of Kenosha within the watershed were given moderate urban potential ratings. Less than 10 percent of the rural area is designated by a high or very high pollution potential rating, with nearly 90 percent of the area being classified as having low or moderate potential ratings. The areas of very high rural pollution potential were relatively scattered throughout the watershed.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency

Table 70

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE PIKE RIVER WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | -- | -- | 2,812 | 9 | 2,812 | 9 |
| High . . . . . | -- | -- | -- | -- | -- | -- |
| Moderate. . . | 471 | 39 | 21,986 | 71 | 22,457 | 69 |
| Low. . . . . . | 737 | 61 | 5,680 | 18 | 6,417 | 20 |
| Very Low . . | -- | -- | 736 | 2 | 736 | 2 |
| Total | 1,208 | 100 | 31,214 | 100 | 32,422 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Pike River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution. The need for additional urban land management practices should be locally investigated for water quality analysis area 8, which drains the northern tip of the City of Kenosha, if the practices identified above were not found to be sufficient to meet the water quality standards. Phosphorus contributions from this urban area may be of sufficient magnitude to significantly degrade the water quality of the Pike River within the City of Kenosha.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Pike River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding facilities, are needed to sufficiently reduce pollutant loadings from all animal operations. In addition, those animal operations located less than 500 feet from a stream and in a high or very high pollution potential area (see Map 24) may require manure storage through the winter in a dry stacking system incorporating runoff control or in a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff. The control of livestock waste runoff, together with the proper management of onsite sewage treatment systems, is expected to sufficiently alleviate fecal coliform problems in the watershed.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $6.6 million, of which $6.5 million, or 99 percent, would be for urban practices and $94,000, or 1 percent, would be for rural practices, and an average annual operation and maintenance cost of $106,000, of which $58,000, or 55 percent, would be for urban practices and $48,000, or 45 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 71.

Rock River Watershed

The water quality of the Rock River and its major tributaries was simulated for 214 stream reaches and their associated subbasins, with the results reported and statistically analyzed for 19 simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The location of these 19 simulation sites and the corresponding tributary water quality analysis areas are shown on Map 25 and presented in Table 72. Model simulations were conducted for the Bark River, Rubicon River, and Turtle Creek subwatersheds as representative of the

Table 71

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE PIKE RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost | |
|---|---|---|
| | Total Capital (1975-2000) | Average Annual Operation and Maintenance |
| Urban | | |
| Septic System Management[a] . . . . . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . | Minimal | 17,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . . . . . . . . | 880,000 | Minimal |
| Construction Erosion Control Practices . . . . | 5,663,000 | 41,000 |
| Subtotal | $6,543,000 | $ 58,000 |
| Rural | | |
| Minimum Conservation Practices[c] . . . . . . . | 8,000 | 42,000 |
| Livestock Waste Control . . . . . . . . . . . . | 86,000 | 6,000 |
| Subtotal | $ 94,000 | $ 48,000 |
| Total | $6,637,000 | $106,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Pike River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $1,235,000, and an average annual operation and maintenance cost of $34,000.*

[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

Map 25

## WATER QUALITY ANALYSIS AREAS IN THE ROCK RIVER WATERSHED

LEGEND

WATER QUALITY SITES AND AREAS

- WATER QUALITY ANALYSIS AREA BOUNDARY AND NUMBER (2)
- WATER QUALITY SIMULATION SITE
- WATER QUALITY SAMPLING STATION

SEWER SERVICE AREAS AND PRIMARY LAND USES

- EXISTING SEWER SERVICE AREA 1975 - SEPARATE
- PROPOSED INCREMENTAL SEWER SERVICE AREA - 2000
- UNSEWERED URBAN DEVELOPMENT 2000
- PRIMARY ENVIRONMENTAL CORRIDOR 2000
- PRIME AGRICULTURAL LAND 2000
- OTHER RURAL LAND 2000

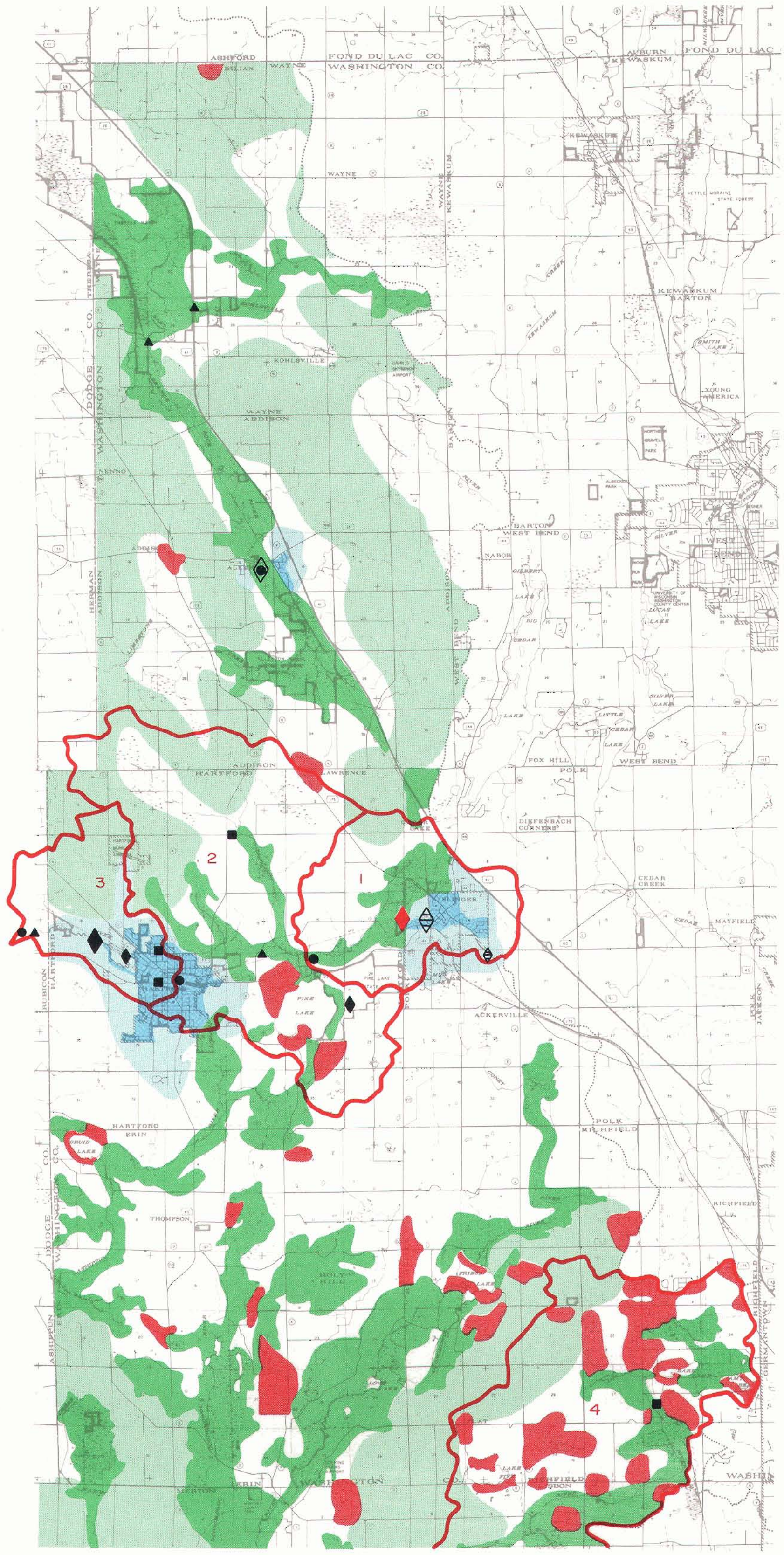
POINT SOURCES OF POLLUTION

- EXISTING PUBLIC SEWAGE TREATMENT PLANT TO BE RETAINED AND TO DISCHARGE EFFLUENT TO SURFACE WATER
- EXISTING PUBLIC SEWAGE TREATMENT PLANT TO BE RETAINED AND TO DISCHARGE EFFLUENT TO LAND
- EXISTING PUBLIC SEWAGE TREATMENT PLANT TO BE ABANDONED
- PROPOSED PUBLIC SEWAGE TREATMENT PLANT TO DISCHARGE EFFLUENT TO SURFACE WATER
- PROPOSED PUBLIC SEWAGE TREATMENT PLANT TO DISCHARGE EFFLUENT TO LAND
- EXISTING PRIVATE SEWAGE TREATMENT PLANT TO BE RETAINED
- EXISTING PRIVATE SEWAGE TREATMENT PLANT TO BE ABANDONED
- KNOWN POINT SOURCE OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANT OR FLOW RELIEF DEVICES

GRAPHIC SCALE

0 1 2 MILES

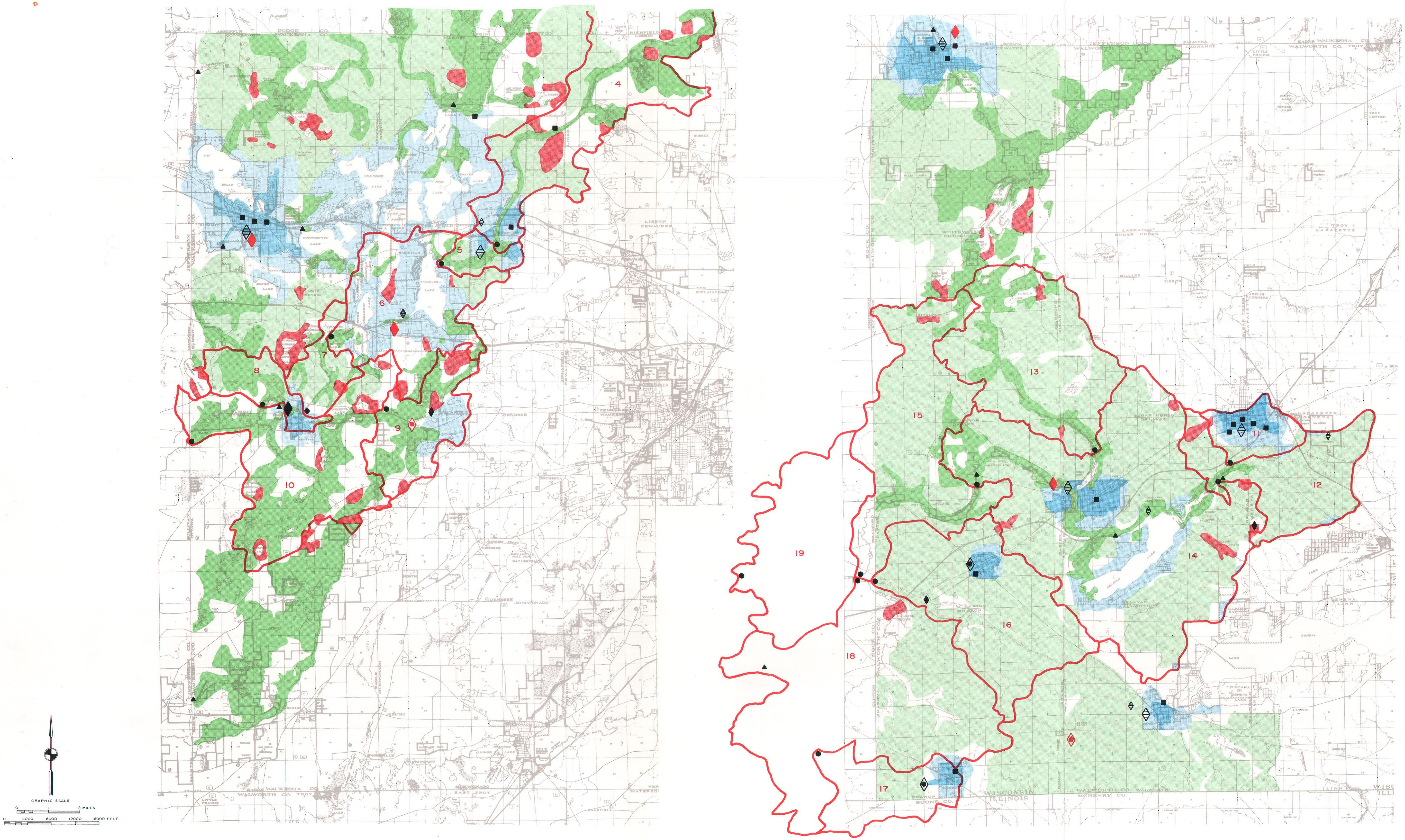
0 4000 8000 12000 16000 FEET




The Rock River watershed has an area of about 684 square miles and ranks second in size and seventh in total resident population of the 12 watersheds in the Region. Within the Rock River watershed there are 214 identified hydrologic subbasins, grouped into 19 water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are 15 sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 62 point sources of water pollution—including 16 sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo a moderate level of urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 10 and 16 percent of the total watershed area, respectively.

*Source: SEWRPC.*

Map 25 (continued)



## Figures 104-120

## EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE ROCK RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 104

WATER QUALITY ANALYSIS AREA 1

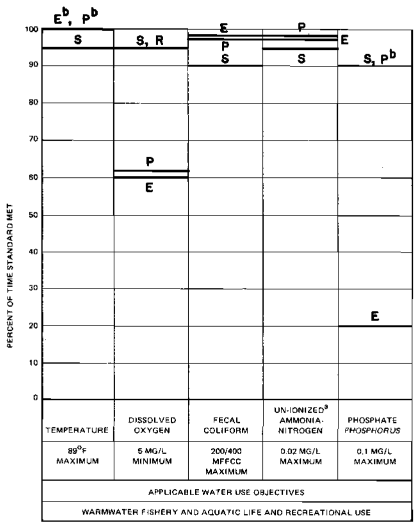



Figure 105

WATER QUALITY ANALYSIS AREA 2

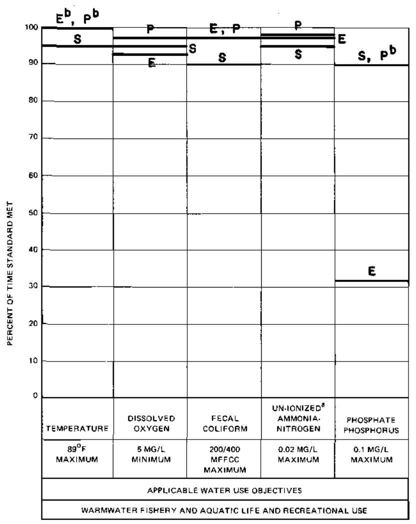


Figure 106

WATER QUALITY ANALYSIS AREA 3

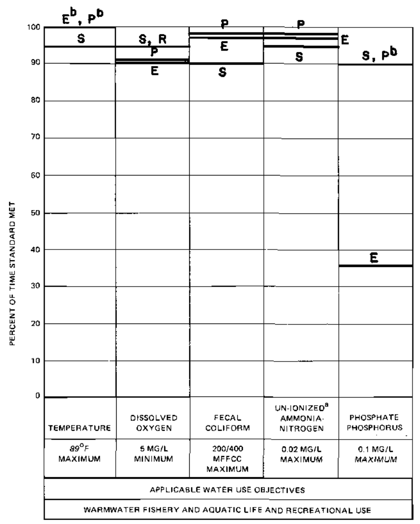


Figure 107

WATER QUALITY ANALYSIS AREA 4

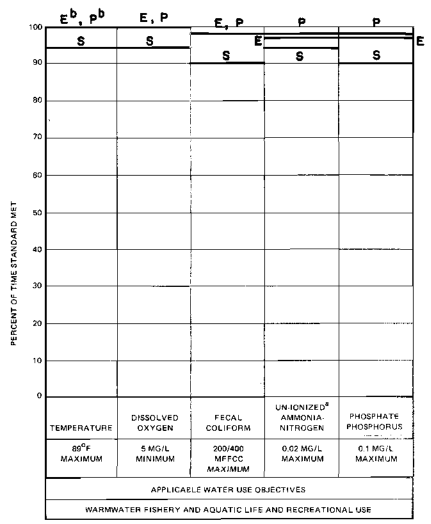


Figure 108

WATER QUALITY ANALYSIS AREA 5

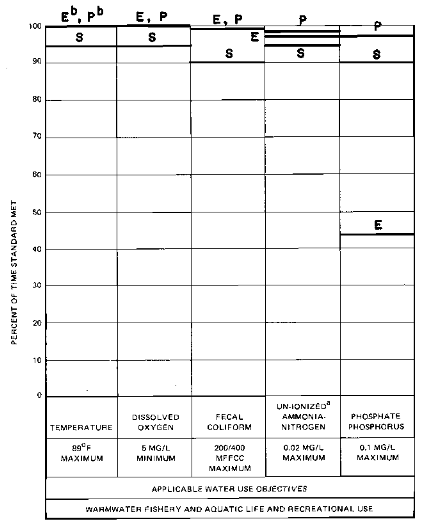


Figure 109

WATER QUALITY ANALYSIS AREA 6

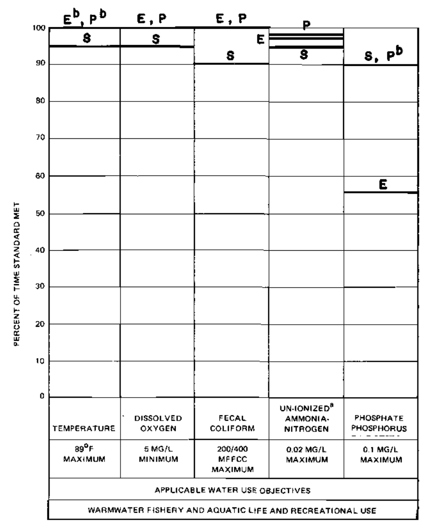


Figure 110

WATER QUALITY ANALYSIS AREA 7

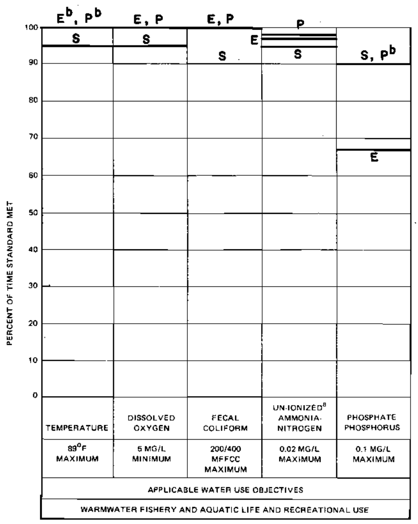


Figure 111

WATER QUALITY ANALYSIS AREA 8

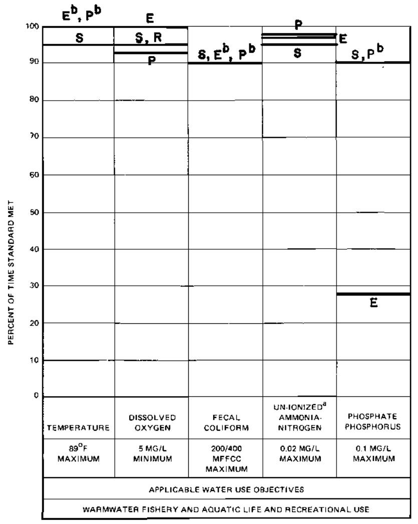


Figure 112

WATER QUALITY ANALYSIS AREA 9

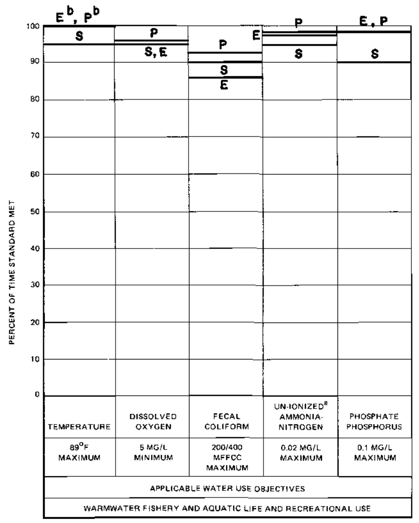


Figure 113

WATER QUALITY ANALYSIS AREA 10

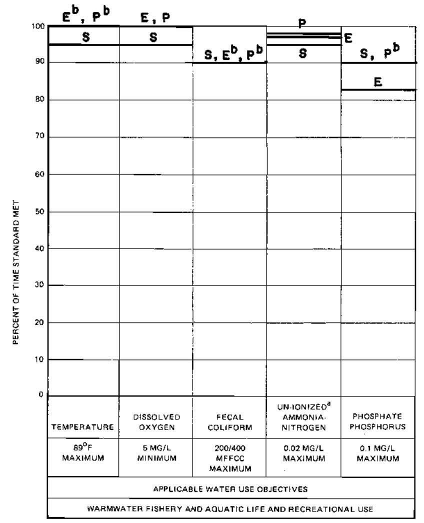


Figure 114

WATER QUALITY ANALYSIS AREA 11

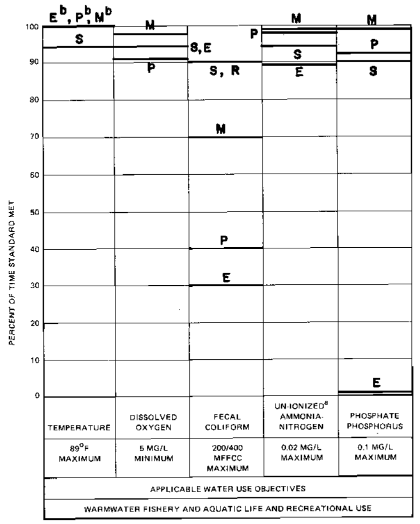


Figure 115

WATER QUALITY ANALYSIS AREA 12

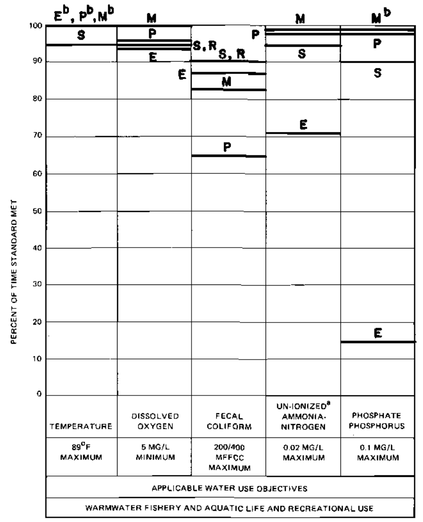


Figure 116

WATER QUALITY ANALYSIS AREA 13

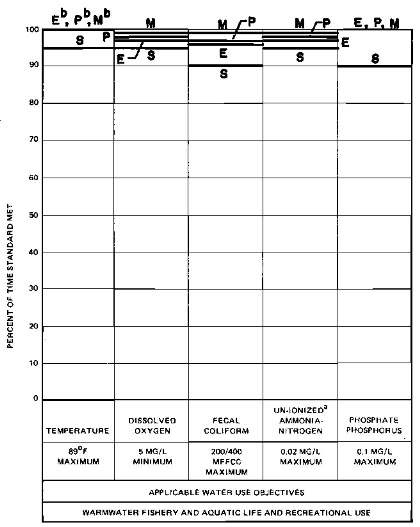


Figure 117

WATER QUALITY ANALYSIS AREA 14

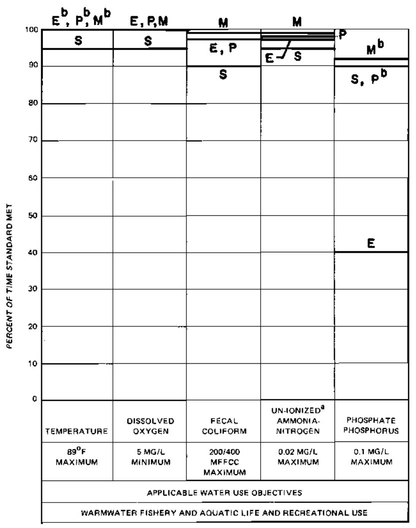


Figure 118

WATER QUALITY ANALYSIS AREA 15

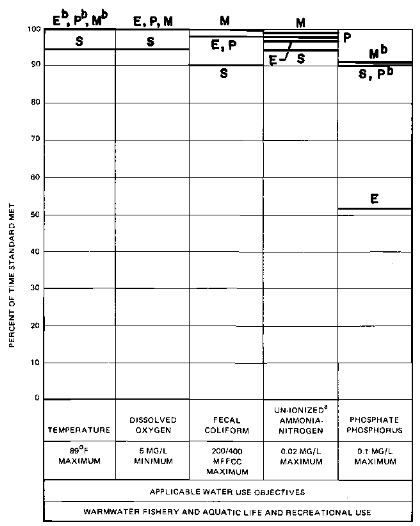


Figure 119

WATER QUALITY ANALYSIS AREA 16

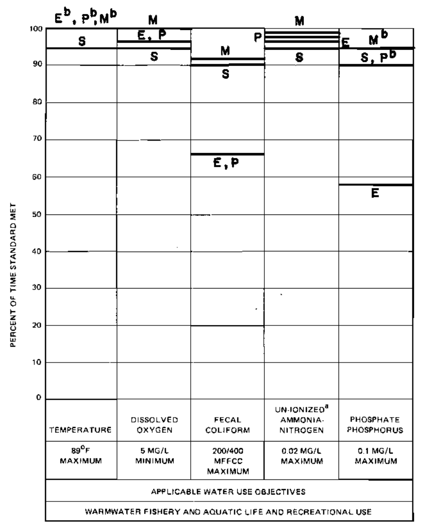
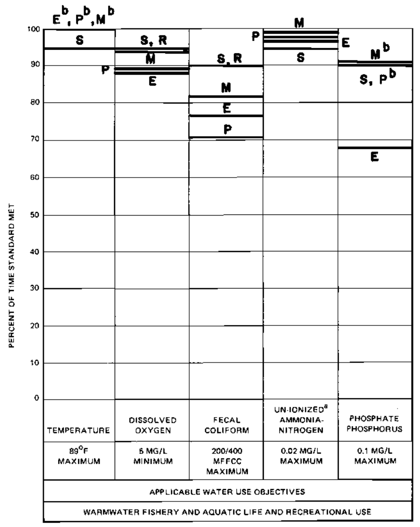


Figure 120

WATER QUALITY ANALYSIS AREA 17



LEGEND

**S** — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

**E** — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

**P** — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**M** — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**R** — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

*Source: SEWRPC.*

Table 72

LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE ROCK RIVER WATERSHED

| Water Quality Analysis Area as Presented on Map 25 | Location of Most Downstream Point Draining the Water Quality Analysis Area | |
|---|---|---|
| | Location | U. S. Public Land Survey Designation |
| | Rubicon River | |
| 1 | At entrance to Pike Lake | T10N, R18E, Section 23 |
| 2 | In Hartford at STH 83 | T10N, R18E, Section 21 |
| 3 | At confluence of Butler Creek | T10N, R17E, Section 13 |
| | Bark River | |
| 4 | Main stem below Hartland at CTH E | T7N, R18E, Section 3 |
| 5 | Main stem at entrance to Nagawicka Lake | T7N, R18E, Section 9 |
| 6 | Main stem at entrance to Crooked Lake | T7N, R17E, Section 23 |
| 7 | Main stem above Dousman | T7N, R17E, Section 34 |
| 8 | Main stem at STH 18 below Utica | T7N, R17E, Section 33 |
| 9 | Scuppernong Creek above Waterville Pond | T6N, R18E, Section 31 |
| 10 | Main Stem at Waukesha-Jefferson County line | T5N, R18E, Section 6 |
| | Turtle Creek | |
| 11 | Jackson Creek Tributary below Elkhorn | T2N, R16E, Section 12 |
| 12 | Jackson Creek at entrance to Delavan Lake | T2N, R16E, Section 12 |
| 13 | Main stem at entrance to Comus Lake | T2N, R16E, Section 6 |
| 14 | Main stem below USH 14 | T2N, R15E, Section 10 |
| 15 | Main stem above confluence with Little Turtle Creek | T2N, R14E, Section 25 |
| 16 | Willow Creek at confluence with Turtle Creek | T2N, R14E, Section 36 |
| 17 | Little Turtle Creek below CTH W | T1N, R14E, Section 26 |
| 18 | Little Turtle Creek at confluence with Turtle Creek | T2N, R14E, Section 25 |
| 19 | Main stem at STH 140 | T2N, R14E, Section 29 |

*Source: SEWRPC.*

middle, upper, and lower portions of the Rock River watershed in the Region. These simulations provided the basis for the analysis of the remaining areas of the Rock River watershed. The following discussion and Figures 104 through 122 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions under various levels of diffuse source control.

An unnamed tributary to the east branch of the Rock River, Bluff Creek, and Scuppernong River is classified for trout fishery and aquatic life and recreational use. All other streams in the Rock River watershed within the Region are classified for warmwater fish and aquatic life and recreational use.

Temperature: It is apparent from Figures 104 through 122 that the temperature standard of 89°F is satisfied within the Rock River watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: In general, only minimum diffuse source controls will be necessary to satisfy the warmwater fishery and aquatic life dissolved oxygen standard of 5 milligrams per liter (mg/l) within the Rock River watershed. However, dissolved oxygen problems are indicated in water quality analysis area 1, which is drained by the Rubicon River and located downstream of the Slinger wastewater treatment facility; water quality analysis area 3, which is also drained by the Rubicon River and located downstream of both the Slinger and Hartford wastewater treatment facilities; analysis area 8, which is drained by the Bark River and located downstream of the Dousman wastewater treatment facility; analysis area 11, which is drained by Jackson Creek and presently located downstream of the existing Elkhorn wastewater treatment facility and industrial wastewater sources; and analysis area 17, which is drained by Little Turtle Creek and located downstream of the Sharon wastewater treatment facility. These problems are probably caused by high oxygen demand from bottom deposits and benthic organisms, and are estimated to be mainly attributable to historical and existing contributions from point and perhaps diffuse sources. Upon the control of these point sources under plan year 2000 conditions and the implementation of minimum diffuse source controls, it is expected that these bottom deposits will either stabilize or be assimulated by the stream system. If, following the implementation of pollution control measures, the benthic oxygen demand is not sufficiently reduced, the possibility of channel dredging activities should be investigated to facilitate the stabilization of some severe areas. Diffuse sources are not expected to cause dissolved oxygen problems in the portions of the Rock River watershed which were not simulated, although similar problems may occur wherever significant point source contributions exist.

Fecal Coliform: Water quality analysis areas 11, 12, 16, 17, and 18 in the Turtle Creek subwatershed, which has a relatively high concentration of livestock operations, are expected to require an estimated 50 percent or higher reduction in diffuse source fecal coliform loads to satisfy the recreational use fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml). All other analysis areas are expected to satisfy the standard with minimum diffuse source controls.

## Figures 121-122

### EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE ROCK RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 121

WATER QUALITY ANALYSIS AREA 18

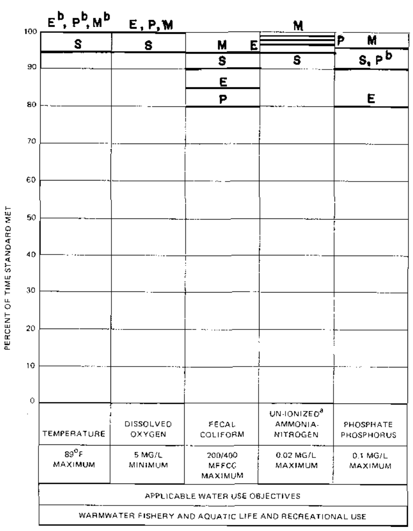
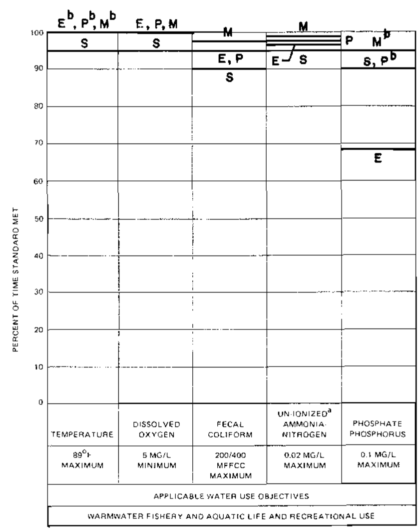



Figure 122

WATER QUALITY ANALYSIS AREA 19




LEGEND

**S** — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

**E** — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

**P** — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**M** — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

**R** — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

*Source: SEWRPC.*

Phosphate-Phosphorus: Following the implementation of the recommended point source controls, the water quality of the streams in the Rock River watershed within the Region can be expected to satisfy the applicable phosphorus standard of 0.1 mg/l with minimum diffuse source controls.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Rock River watershed indicate that the level of 0.02 mg/l is seldom exceeded. Diffuse source controls will not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Summary: Table 73 presents the general level of diffuse source pollutant loading reductions necessary to satisfy the applicable water quality standards for the watershed. Required reduction values are shown for each simulated water quality analysis area and for each pollutant for which a standard has been recommended. In general, only a 50 percent reduction in diffuse source fecal coliform loadings is required in some areas within the watershed. All other water quality standards are expected to be met without diffuse source controls.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Rock River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 26 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 74 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

## Table 73

### REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE ROCK RIVER WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum[a] | Minimum | Minimum | Minimum |
| 2 | Minimum | Minimum | Minimum | Minimum |
| 3 | Minimum[a] | Minimum | Minimum | Minimum |
| 4 | Minimum | Minimum | Minimum | Minimum |
| 5 | Minimum | Minimum | Minimum | Minimum |
| 6 | Minimum | Minimum | Minimum | Minimum |
| 7 | Minimum | Minimum | Minimum | Minimum |
| 8 | Minimum[a] | Minimum | Minimum | Minimum |
| 9 | Minimum | Minimum | Minimum | Minimum |
| 10 | Minimum | Minimum | Minimum | Minimum |
| 11 | Minimum[a] | More than 50 | Minimum | Minimum |
| 12 | Minimum | More than 50 | Minimum | Minimum |
| 13 | Minimum | Minimum | Minimum | Minimum |
| 14 | Minimum | Minimum | Minimum | Minimum |
| 15 | Minimum | Minimum | Minimum | Minimum |
| 16 | Minimum | 50 | Minimum | Minimum |
| 17 | Minimum[a] | More than 50 | Minimum | Minimum |
| 18 | Minimum | 50 | Minimum | Minimum |
| 19 | Minimum | Minimum | Minimum | Minimum |

[a] *Requires reduction in benthic oxygen demand, which is expected to result if point source and minimum diffuse source controls are implemented.*

*Source: SEWRPC.*

Table 74

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE ROCK RIVER WATERSHED:[a] 1975

| Pollution Potential Classification | Urban Areas[b] Area (acres) | Urban Areas[b] Percent of Total Urban Area | Rural Areas[b] Area (acres) | Rural Areas[b] Percent of Total Rural Area | Total Watershed Area (acres) | Total Watershed Percent of Total Watershed Area |
|---|---|---|---|---|---|---|
| Very High . . | -- | -- | 77,578 | 18 | 77,578 | 18 |
| High . . . . . | 469 | 3 | 63,219 | 15 | 63,688 | 15 |
| Moderate. . . | 8,714 | 50 | 146,397 | 35 | 155,111 | 35 |
| Low. . . . . . | 7,855 | 45 | 87,626 | 21 | 95,481 | 22 |
| Very Low . . | 444 | 2 | 45,147 | 11 | 45,591 | 10 |
| Total | 17,482 | 100 | 419,967 | 100 | 437,449 | 100 |

[a] *Includes total areas tributary to the major lakes in the watershed.*

[b] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

The pollution potential classification analysis for the Rock River indicated relatively little variation in urban pollution potential, with 95 percent of the analyzed urban areas receiving a moderate or low rating. Most of the urban areas of significant size outside of direct drainage areas to lakes received a moderate rating, whereas many urban areas which surround lakes received a low urban pollution potential rating. The rural pollution potential varied significantly in comparison to the rest of the Region. Thirty-three percent of the rural area is designated by a high or very high rural pollution potential rating, with most high potential areas located in the Turtle Creek and Whitewater Creek subwatersheds. Several lakes, including Lake Five in Washington County and Whitewater Lake, Comus Lake, and Lake Loraine in Walworth County, are located in areas of high rural pollution potential. Areas of low rural potential exist in the Bark River subwatershed and in the Oconomowoc River subwatershed downstream of North Lake. These two subwatersheds also have an unusually low density of livestock.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Rock River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Rock River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding ponds, are needed to sufficiently reduce pollutant loadings from all animal operations. In addition, those animal operations located less than 500 feet from a stream and in a high or very high pollution potential area (see Map 26) may require manure storage through the winter in a dry stacking system incorporating runoff control or in a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff. The control of livestock waste runoff, together with the management of septic tank systems and the provision of sanitary sewer service where needed, is expected to sufficiently alleviate the fecal coliform problems in the watershed.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $27.4 million, of which $22.6 million, or 82 percent, would be for urban practices and $4.9 million, or 18 percent, would be for rural practices, and an average annual operation and maintenance cost of $888,000, of which $197,000, or 22 percent, would be for urban practices and $691,000, or 78 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 75.

Table 75

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE ROCK RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] . . . . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . | Minimal | 65,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . . . . . . . . | 1,496,000 | Minimal |
| Construction Erosion Control Practices . . . . | 21,067,000 | 132,000 |
| Subtotal | $22,563,000 | $197,000 |
| Rural | | |
| Minimum Conservation Practices[c] . . . . . . . | 67,000 | 404,000 |
| Livestock Waste Control . . . . . . . . . . . . | 4,791,000 | 287,000 |
| Subtotal | $ 4,858,000 | $691,000 |
| Total | $27,421,000 | $888,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Rock River watershed. However, because septic tank system management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $1,539,000, and an average annual operation and maintenance cost of $335,000.*

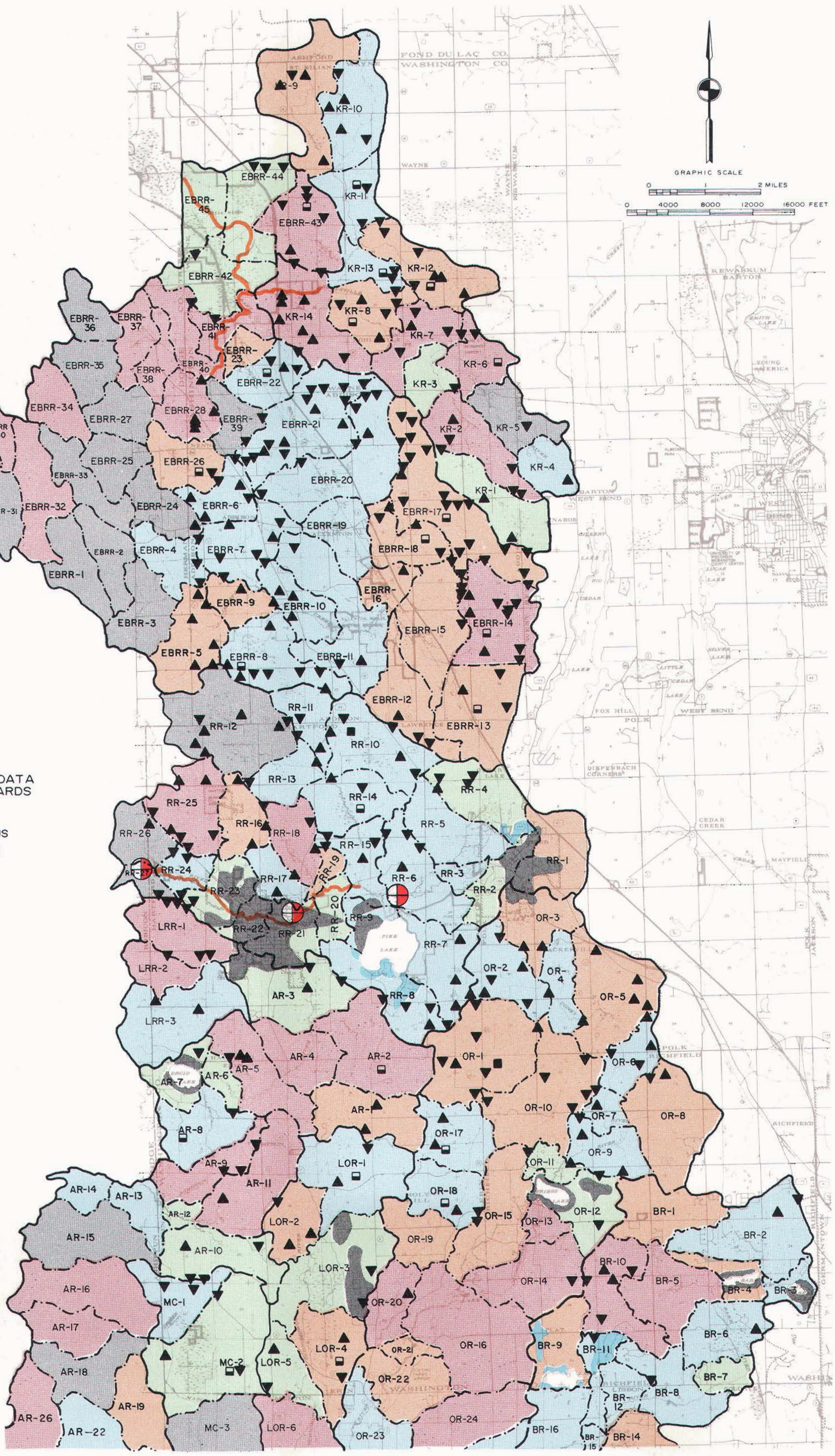
[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

## Map 26

## DIFFUSE SOURCE POLLUTION POTENTIAL IN THE ROCK RIVER WATERSHED




LEGEND

HYDROLOGIC BOUNDARIES

- WATERSHED
- SUBWATERSHED
- RR-I SUBBASIN AND NUMBER
- RURAL AREA OF VERY HIGH POTENTIAL
- URBAN AREA OF HIGH POTENTIAL
- RURAL AREA OF HIGH POTENTIAL
- URBAN AREA OF MODERATE POTENTIAL
- RURAL AREA OF MODERATE POTENTIAL
- URBAN AREA OF LOW POTENTIAL
- RURAL AREA OF LOW POTENTIAL
- URBAN AREA OF VERY LOW POTENTIAL
- RURAL AREA OF VERY LOW POTENTIAL
- SUBBASIN WITH EXISTING CONSERVATION PRACTICES IMPLEMENTED AT 20 OR MORE SITES, 1964–1975
- SUBBASIN WITH EXISTING CONSERVATION PRACTICES IMPLEMENTED AT 6–19 SITES, 1964–1975 (NO SYMBOL SHOWN FOR 5 OR FEWER SITES)

KNOWN LIVESTOCK HERDS WITH MORE THAN 25 EQUIVALENT ANIMAL UNITS

- ▲ LOCATED WITHIN 500 FEET FROM A STREAM
- ▼ LOCATED MORE THAN 500 FEET FROM A STREAM

COMPARISON OF SIMULATED WATER QUALITY DATA TO THE RECOMMENDED WATER QUALITY STANDARDS AT SIMULATED OUTPUT SITES

FECAL FORM — TOTAL PHOSPHORUS
AMMONIA-NITROGEN — DISSOLVED OXYGEN

- STANDARDS ARE MET
- STANDARDS ARE NOT MET

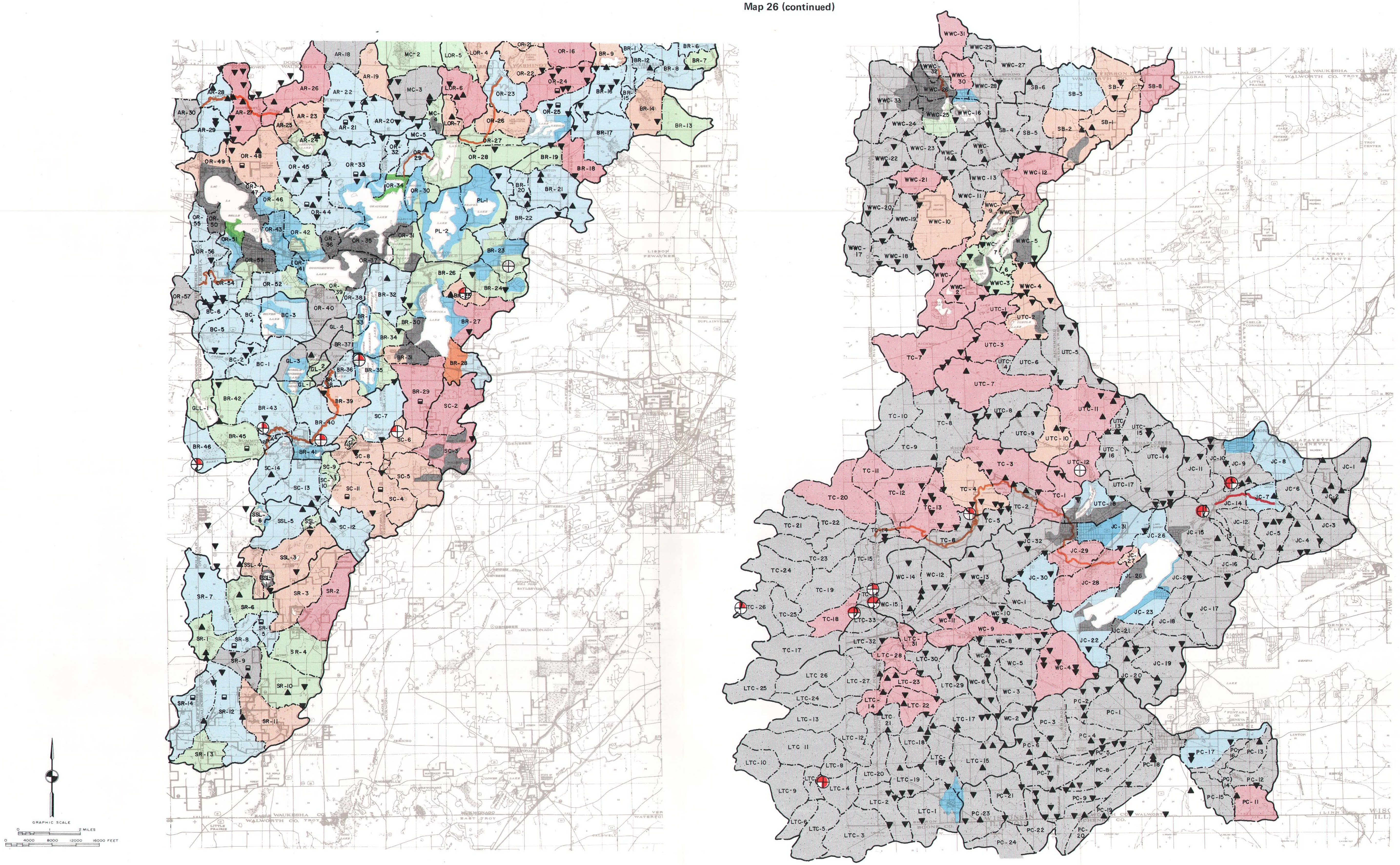
STREAM REACHES WITH COMPUTED WATER QUALITY INDEX RATINGS

- POOR WATER QUALITY
- FAIR WATER QUALITY
- EXCELLENT WATER QUALITY

The hydrologic subbasins in the Rock River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 17,482 acres devoted to urban land uses in the watershed, 50 percent recorded a moderate rating for nonpoint source pollution, with virtually all of the remaining area recording a low or very low rating. Of the 419,967 acres devoted to rural land uses in the watershed, 33 percent was estimated to have a high or very high pollution potential, 35 percent a moderate potential, and 32 percent a low or very low potential for rural nonpoint source pollution. Thus, as of 1975, the Rock River watershed exhibited a moderate to low potential for urban nonpoint source pollution and a wide range of potential for rural nonpoint source pollution.

*Source: SEWRPC.*

Map 26 (continued)



Root River Watershed

The water quality of the Root River and its major tributaries was simulated for 136 stream reaches and their associated subbasins, with the results reported and statistically analyzed for 16 simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. For most of the watershed, the national goals of water quality suitable to support a warmwater fishery and recreational use are achievable. The simulation model studies have indicated, however, that it may not be possible to achieve the water quality standards associated with the warmwater fishery and aquatic life and recreational use objectives in the Root River Canal even with extensive point and diffuse source controls, and therefore the Canal is classified for limited fishery and aquatic life and limited recreational use. Existing and historical point and diffuse sources of pollution have severely polluted the Root River Canal. The sediments which have been deposited in the canals are believed to exert a high oxygen demand. The Commission analyses and the calibration and use of the water quality simulation model relied upon the calibration data obtained from water quality sampling under these severely polluted conditions. Because of the poor existing water quality of the canals and the critical role of these in-place pollutants, it is not possible to predict precisely the extent to which future achievement of the desired water quality goals may be achieved. While it is expected that these pollutant-rich sediments will either flush out of the stream system or stabilize, the rate and extent to which these factors will affect water quality are unknown. In view of this condition, further analyses should be conducted to determine whether or not a higher level of water use objectives could be achieved. This further analysis will most suitably be conducted following implementation of the point source controls recommended in the Root River Canal subregional area discussion, and the diffuse source controls discussed below. Although six simulation sites were located on the Root River Canal, model simulation results are presented in this section only for the most downstream simulation site. The location of this simulation site and the remaining 10 simulation sites within the Root River watershed, and the corresponding tributary water quality analysis areas, are shown on Map 27 and presented in Table 76. For the Root River watershed, the following discussion and Figures 123 through 133 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions with point source controls only, and with point source controls coupled with a 25 or 50 percent reduction in diffuse source pollutant loadings.

The comprehensive plan for the Root River watershed, as documented in SEWRPC Planning Report No. 9, recommends the construction of a 660-acre multipurpose reservoir at the confluence of the Root River and the Root River Canal in the City of Franklin, Milwaukee County. However, analyses conducted under the areawide water quality management planning program and documented in Volume Three, Chapter II of this report indicated that such a reservoir would be expected to exhibit significant water quality problems necessitating costly water quality management measures. It was, therefore, concluded that the construction of the proposed reservoir should be reconsidered by the Root River Watershed Committee. The analyses presented in this section, therefore, assume that the reservoir would not be constructed during this plan period.

Table 76

LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE ROOT RIVER WATERSHED

| Water Quality Analysis Area as Presented on Map 27 | Location of Most Downstream Point Draining the Water Quality Analysis Area: Location | U. S. Public Land Survey Designation |
|---|---|---|
| | Root River | |
| 1 | Village of Greendale, east of Hales Corners Airport | T5N, R21E, Section 4 |
| 3 | City of Franklin, north of Ryan Road | T5N, R21E, Section 22 |
| 4 | City of Franklin, south of STH 100 | T5N, R21E, Section 34 |
| 6 | Town of Caledonia, east of Caddy Vista | T4N, R22E, Section 3 |
| 7 | Town of Caledonia, east of STH 38 | T4N, R22E, Section 26 |
| 10 | City of Racine, north of intersection between STH 38 and CTH MM | T3N, R23E, Section 6 |
| 11 | City of Racine, at confluence with Lake Michigan | T3N, R23E, Section 9 |
| | Hoods Creek | |
| 8 | Town of Mt. Pleasant, south of CTH K | T3N, R22E, Section 4 |
| 9 | Town of Caledonia, east of STH 38 | T4N, R22E, Section 26 |
| | Root River Canal | |
| 5 | City of Franklin, west of S. 60th Street, south of W. Oakwood Road | T5N, R21E, Section 34 |
| | Tess Corners Creek | |
| 2 | Village of Greendale, east of Whitnall Park | T5N, R21E, Section 4 |

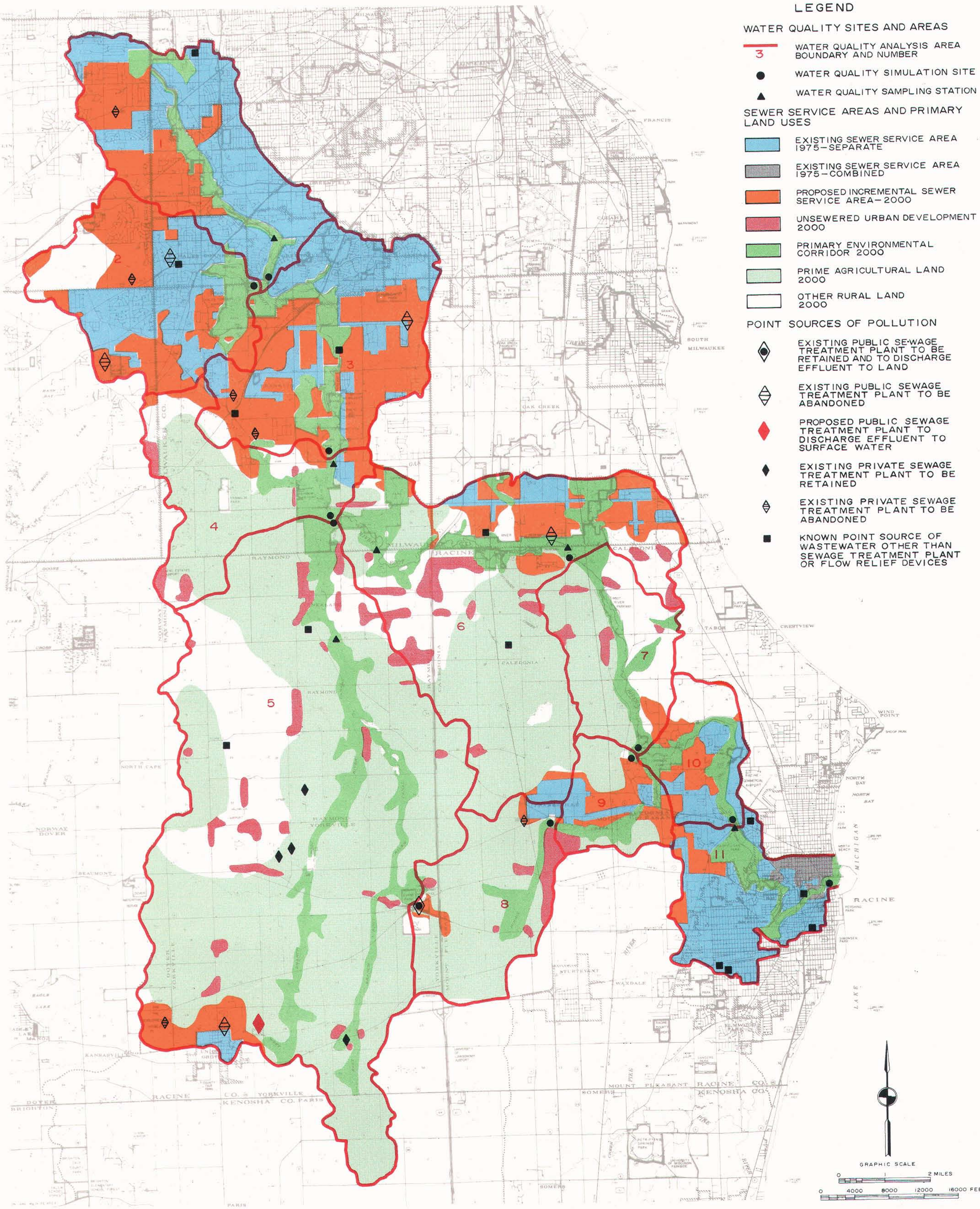
*Source: SEWRPC.*

Temperature: It is apparent from Figures 123 through 133 that the temperature standard of 89°F is expected to be met within the Root River watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: Under plan year 2000 conditions, dissolved oxygen problems are indicated in water quality analysis areas 5 and 6. The dissolved oxygen problem in analysis area 5, which is drained by the Root River Canal, is attributed to extreme point source loads to the Canal under existing conditions, and the problem in analysis area 6 is apparently caused by inflow of poor

## Map 27

### WATER QUALITY ANALYSIS AREAS IN THE ROOT RIVER WATERSHED




The Root River watershed has an area of 197 square miles and ranks fourth in size and sixth in total resident population of the 12 watersheds in the Region. Within the Root River watershed there are 136 identified hydrologic subbasins grouped into 16 water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are six sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were 90 point sources of water pollution—including 61 sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo a moderate level of urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 26 and 31 percent of the total watershed area, respectively.

*Source: SEWRPC.*

# EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE ROOT RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 123

WATER QUALITY ANALYSIS AREA 1

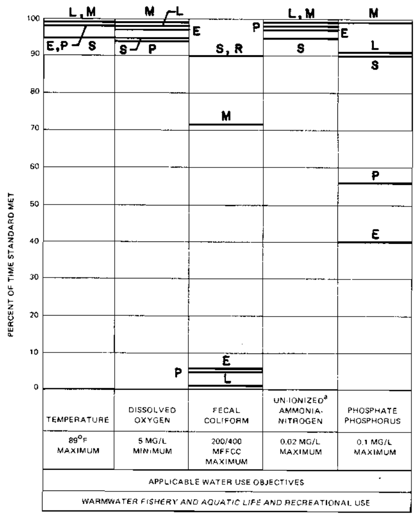



Figure 124

WATER QUALITY ANALYSIS AREA 2

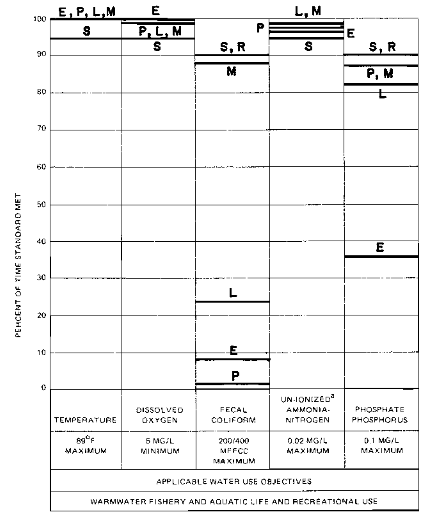



Figure 125

WATER QUALITY ANALYSIS AREA 3

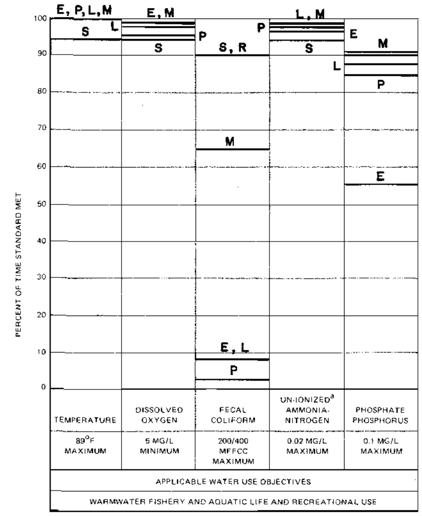



Figure 126

WATER QUALITY ANALYSIS AREA 4

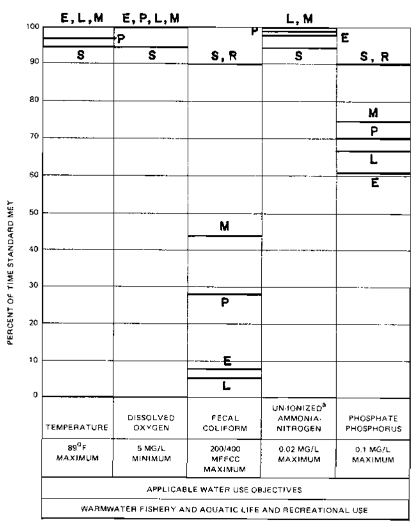



Figure 127

WATER QUALITY ANALYSIS AREA 5

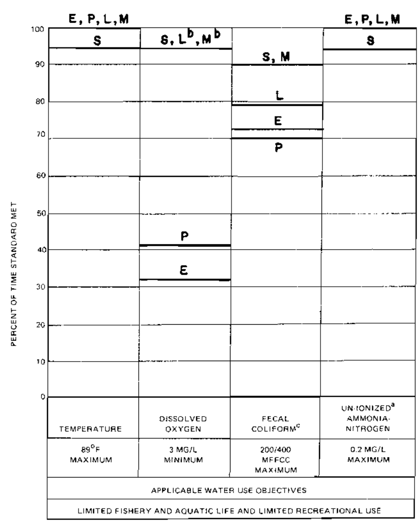



Figure 128

WATER QUALITY ANALYSIS AREA 6

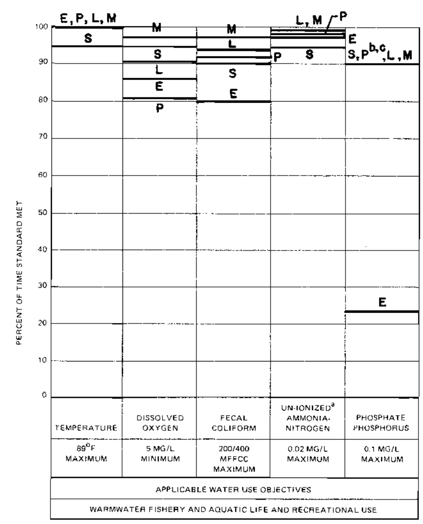



Figure 129

WATER QUALITY ANALYSIS AREA 7

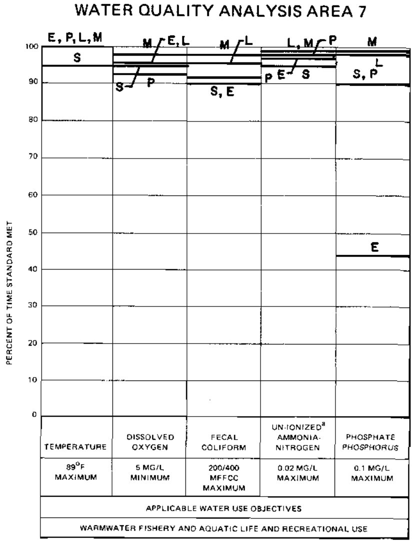



Figure 130

WATER QUALITY ANALYSIS AREA 8

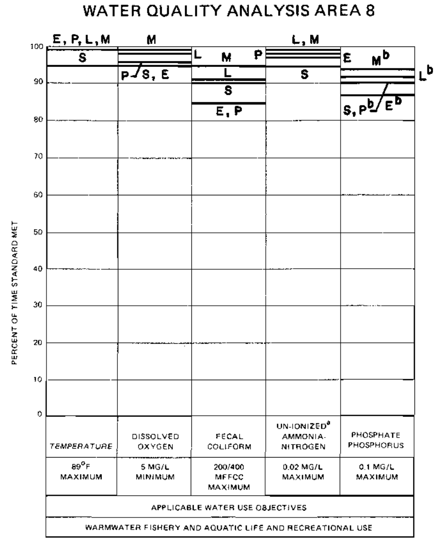
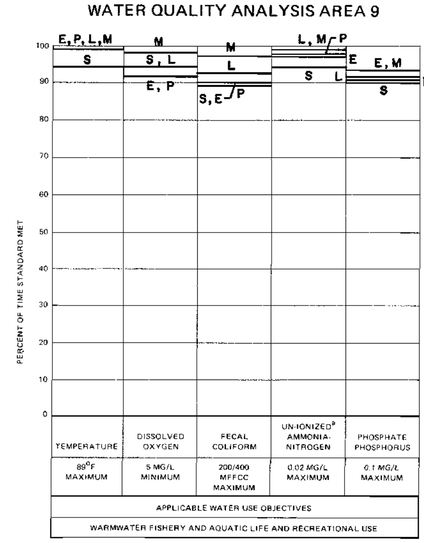



Figure 131

WATER QUALITY ANALYSIS AREA 9



Figures 132-133

## EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE ROOT RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

*Figure 132*

WATER QUALITY ANALYSIS AREA 10

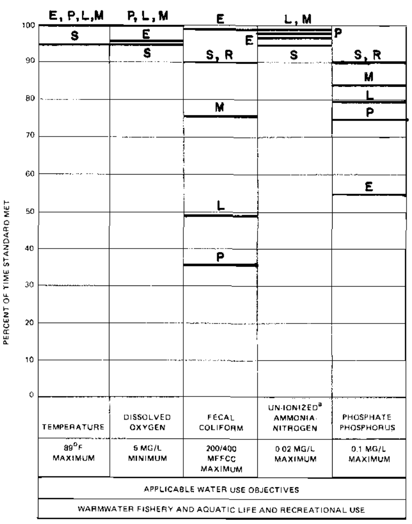
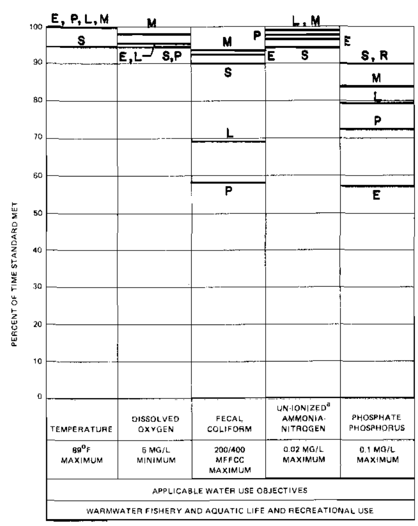



*Figure 133*

WATER QUALITY ANALYSIS AREA 11




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

L — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A LOW (25%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

M — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND A MODERATE (50%) LEVEL OF REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

[c] *SIMULATION ANALYSES INDICATE THAT THE PHOSPHORUS STANDARD CANNOT BE MET WITHOUT A 50 TO 75 PERCENT REDUCTION IN DIFFUSE SOURCE LOADS TO THE ROOT RIVER CANAL. THIS LEVEL OF STANDARD ACHIEVEMENT, THEREFORE, ASSUMES THIS LEVEL OF DIFFUSE SOURCE CONTROL IN THE ROOT RIVER CANAL DRAINAGE AREA, WATER QUALITY ANALYSIS AREA 5.*

*Source: SEWRPC.*

quality water from the Root River Canal to the Root River main stem. Upon the implementation of recommended measures in the Root River Canal subwatershed, dissolved oxygen levels in analysis area 5 are expected to satisfy the desired standard for the support of a limited fishery. The satisfaction of the dissolved oxygen standard for the support of a warmwater fishery in analysis area 6 is contingent on the effectiveness of pollution abatement measures to increase dissolved oxygen levels in the inflow from the Root River Canal. If the dissolved oxygen levels in the Root River Canal cannot be sufficiently increased by the measures recommended in this plan, then instream aeration at the lower end of the Root River Canal should be considered, as should dredging of in-place pollutants in the canals to meet the dissolved oxygen standard in the Root River main stem. Additional diffuse source control in water quality analysis area 6 is not expected to be required to satisfy the dissolved oxygen standard.

Fecal Coliform: The water quality analysis areas which contain significant urban areas—areas 1, 2, 3 4, 10, and 11—and analysis area 5, which is drained by the Root River Canal, are expected to require a 50 percent or greater reduction in diffuse source fecal coliform loads to satisfy the fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml). All other water quality analysis areas within the Root River watershed—except analysis area 8—may be expected to satisfy the fecal coliform standard without diffuse source controls. Area 8 requires a 25 percent reduction in order to satisfy the fecal coliform standard.

Phosphate-Phosphorus: As with fecal coliform, those water quality analysis areas which contain significant urban areas—areas 1, 2, 3, 4, 10, and 11—will require at least a 25 percent diffuse source control to satisfy the phosphorus standard of 0.1 milligram per liter (mg/l) at least 90 percent of the time. The analyses also indicate that a phosphorus standard cannot be met in analysis area 6 unless diffuse source phosphorus loads in the Root River Canal, which drains analysis area 5, are reduced by 50 to 75 percent. Therefore, diffuse source controls are required to reduce phosphorus in analysis area 5, even though no phosphorus standard applies to the Root River Canal. No additional controls are needed in analysis area 6. Analysis areas 7, 8, and 9 may be expected to satisfy the standard at least 90 percent of the time without diffuse source controls assuming the recommended point source controls are implemented.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Root River watershed indicate that the levels of 0.02 mg/l in most of the watershed and 0.2 mg/l in the Root River Canal should seldom be exceeded. Diffuse source controls are not indicated to be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Summary: Table 77 presents the general level of diffuse source pollutant loading reductions and bottom oxygen demand reductions necessary to satisfy the applicable water quality standards for the Root River watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended. In general, a 50 percent or greater reduction in diffuse source fecal coliform and phosphate-phosphorus loads are required in the urban areas of the Root River watershed, and a 50 percent reduction in fecal coliform loads and a 50 to

Table 77

REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE ROOT RIVER WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum | More than 50 | Minimum | 25 |
| 2 | Minimum | More than 50 | Minimum | More than 50 |
| 3 | Minimum | More than 50 | Minimum | 50 |
| 4 | Minimum | More than 50 | Minimum | More than 50 |
| 5 | Minimum[a] | 50 | Minimum | 50 to 75[c] |
| 6 | Minimum[b] | Minimum | Minimum | Minimum[b] |
| 7 | Minimum | Minimum | Minimum | Minimum |
| 8 | Minimum | 25 | Minimum | Minimum |
| 9 | Minimum | Minimum | Minimum | Minimum |
| 10 | Minimum | More than 50 | Minimum | More than 50 |
| 11 | Minimum | More than 50 | Minimum | More than 50 |

[a] *Assumes at least a 75 percent reduction in benthic oxygen demand.*

[b] *Requires reduction in organic and diffuse source phosphorus loads from the Root River Canal, expected to result from implementation of measures recommended for that subwatershed.*

[c] *Although no phosphorus standard has been recommended for the Root River Canal, which drains analysis area 5, phosphorus reductions are needed to permit the Root River main stem downstream of the confluence with the Canal to meet the phosphorus standard.*

*Source: SEWRPC.*

75 percent reduction in phosphorus loads is required for the Root River Canal drainage area. In addition, a significant reduction in bottom oxygen demand is required in the Root River Canal.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Root River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 28 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 78 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

The pollution potential classification analysis for the Root River watershed indicated relatively little variation in urban pollution potential, with 70 percent of the analyzed urban areas receiving a moderate rating. Several areas of high urban pollution potential were located in the portion of the City of Racine within the watershed. The rural pollution potential varied significantly in comparison to the rest of the Region. The rural analysis indicated that 17 percent of the rural area is designated by a high or very high pollution potential

Table 78

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE ROOT RIVER WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | -- | -- | 11,958 | 12 | 11,958 | 10 |
| High . . . . . | 130 | 1 | 4,964 | 5 | 5,094 | 4 |
| Moderate. . . | 15,596 | 70 | 55,431 | 53 | 71,027 | 56 |
| Low. . . . . . | 5,524 | 25 | 19,817 | 19 | 25,341 | 20 |
| Very Low . . | 919 | 4 | 11,658 | 11 | 12,577 | 10 |
| Total | 22,169 | 100 | 103,828 | 100 | 125,997 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

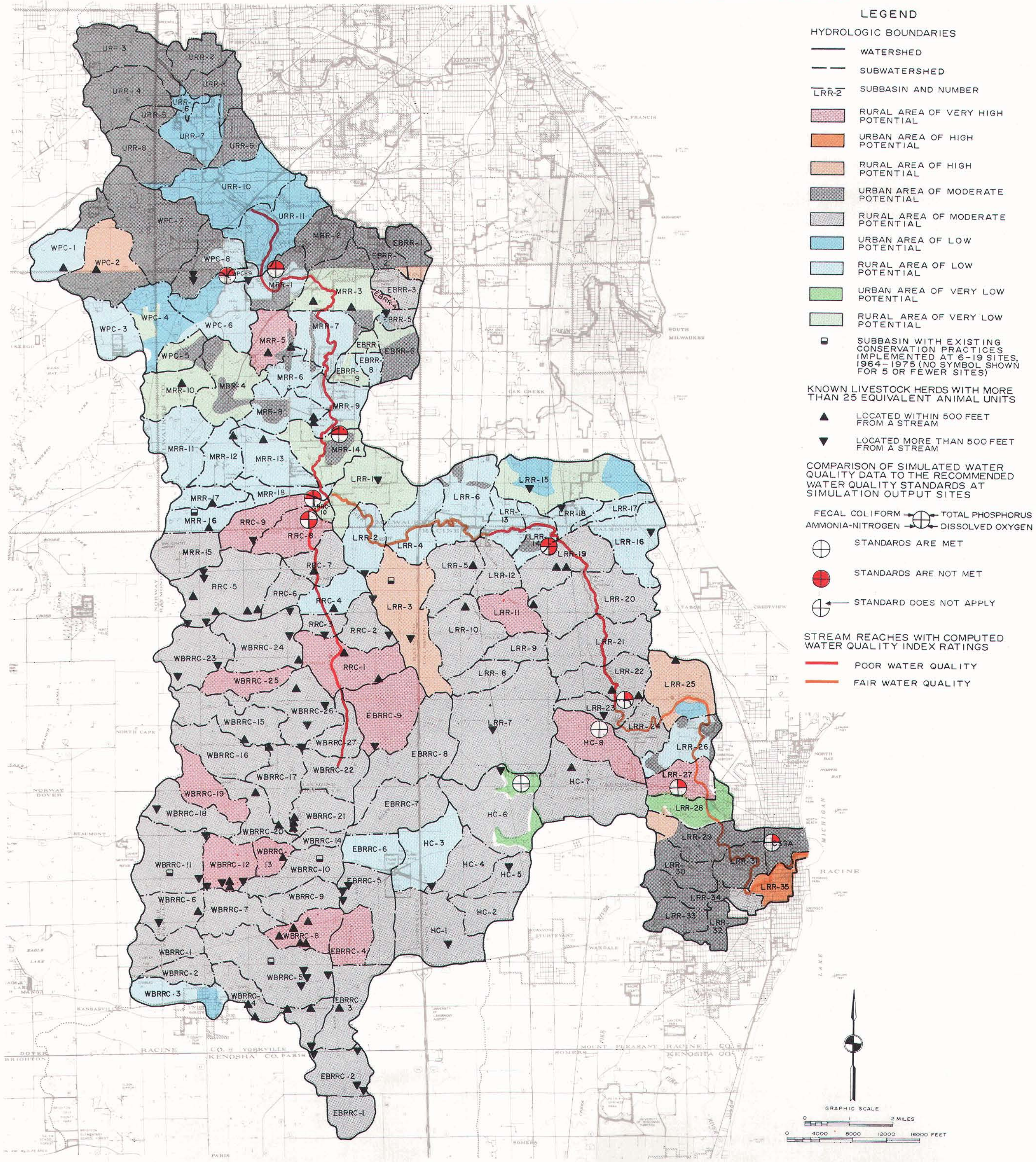
rating, with these areas scattered throughout the watershed. In general, the northern half of the watershed has a lower rural pollution potential rating than does the southern half.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should be implemented in the entire Root River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution.

These low-cost and minimum urban practices alone, however, are not anticipated to provide a sufficient level of urban diffuse source pollution control for the Root River watershed. Many other measures will need to be instituted, including improved street sweeping practices, with improved vacuum sweepers and increased sweeping frequencies, along with supporting parking ordinances; improved street maintenance and refuse collection and disposal; improved and more frequent leaf collection with vacuum sweepers; increased catch basin cleaning in existing areas; and streambank protection measures.

## Map 28

### DIFFUSE SOURCE POLLUTION POTENTIAL IN THE ROOT RIVER WATERSHED




The hydrologic subbasins in the Root River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the total 22,169 acres devoted to urban land uses in the watershed, 70 percent recorded a moderate potential rating for nonpoint source pollution, with nearly all of the remaining area recording a low or very low rating. Of the 103,828 acres devoted to rural land uses in the watershed, 17 percent was estimated to have a high or very high potential, 53 percent a moderate potential, and the remaining 30 percent a low or very low potential for rural nonpoint source pollution. Thus, as of 1975, the Root River watershed exhibited a moderate potential for both urban and rural nonpoint source pollution.

*Source: SEWRPC.*

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Root River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding ponds, are needed to control pollutant loadings from all animal operations. In addition, those animal operations located less than 500 feet from a stream and in high or very high pollution potential areas (see Map 28) may require manure storage through the winter in a dry stacking system incorporating runoff control or in a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff. In the Root River Canal drainage area, additional conservation practices, such as crop rotation, contour strip-cropping, grass waterways, diversions, wind erosion controls, streambank protection measures, vegetative buffer strips, and terraces, are also expected to be required to reduce phosphorus runoff and thereby enable the Root River main stem to satisfy the phosphorus standard. These additional practices are generally not thought to be needed in the other areas of the watershed. As with urban diffuse source controls, only minimum rural diffuse source controls should be initially applied, with the need for additional controls to be reevaluated following point source control implementation.

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $15.9 million, of which $14.2 million, or 89 percent, would be for urban practices and $1.7 million, or 11 percent, would be for rural practices, and an average annual operation and maintenance cost of $2.0 million, of which $1.7 million, or 85 percent, would be for urban practices and $290,000, or 15 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 79.

Sauk Creek Watershed: The water quality of Sauk Creek and its major tributaries was simulated for 35 stream reaches and their associated subbasins, with the results reported and statistically analyzed for four simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The location of these four simulation sites and the corresponding tributary water quality analysis areas are shown on Map 29 and presented in Table 80. The following discussion and Figures 134 through 137 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions. Sauk Creek is classified for warmwater fishery and aquatic life and recreational use.

Table 79

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE ROOT RIVER WATESHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] | Minimal | 143,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures | 1,727,000 | Minimal |
| Additional Urban Diffuse Source Controls[c] | 1,606,000 | 1,465,000 |
| Construction Erosion Control Practices | 10,851,000 | 79,000 |
| Subtotal | $14,184,000 | $1,687,000 |
| Rural | | |
| Minimum Conservation Practices[d] | 24,000 | 157,000 |
| Additional Conservation Practices[e] | 674,000 | 68,000 |
| Livestock Waste Control | 1,054,000 | 65,000 |
| Subtotal | $ 1,748,000 | $ 290,000 |
| Total | $15,932,000 | $1,977,000 |

*[a] The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Root River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $6,764,000, and an average annual operation and maintenance cost of $178,000.*

*[b] Low-cost urban practices include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

*[c] Additional urban diffuse source controls necessary to achieve a 50 percent reduction in urban diffuse source loads include increased street sweeping, improved street maintenance and refuse collection and disposal, streambank protection measures, increased catch basin cleaning, and increased leaf and vegetation debris collection and disposal.*

*[d] Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*[e] Additional conservation practices necessary to achieve a further 50 percent reduction in rural land runoff loads include crop rotation, contour strip-cropping, grass waterways, diversions, wind erosion controls, terraces, streambank protection, and vegetative buffer strips. These practices are recommended only in the Root River Canal drainage area.*

*Source: SEWRPC.*

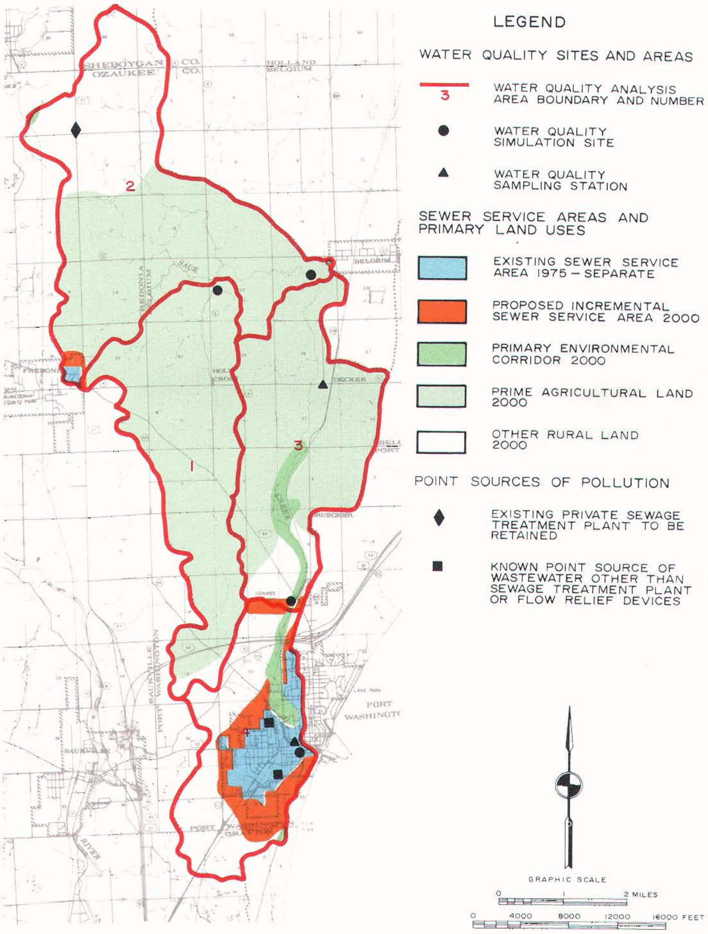
Temperature: It is apparent from Figures 134 through 137 that the temperature standard of 89°F is satisfied within the Sauk Creek watershed and that pollutant loading reductions have a negligible effect on temperature. The temperature standard may be expected to be exceeded less than 1 percent of the time.

Dissolved Oxygen: No diffuse source controls will be necessary to satisfy the warmwater fishery and aquatic life dissolved oxygen standard of 5 milligrams per liter (mg/l) within the Sauk Creek watershed.

Fecal Coliform: All water quality analysis areas within the Sauk Creek watershed may be expected to satisfy a fecal coliform standard of 200/400 membrane filter fecal coliform counts per 100 milliliters (MFFCC/100 ml) under an expected approximate diffuse source pollutant loading reduction of 50 percent.

Map 29

## WATER QUALITY ANALYSIS AREAS IN THE SAUK CREEK WATERSHED




The Sauk Creek watershed has an area of 34 square miles and ranks ninth in size and eleventh in total resident population of the 12 watersheds in the Region. Within the Sauk Creek watershed there are 35 identified hydrologic subbasins grouped into four water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed are two sites for which water quality sampling data were obtained as part of various Commission work programs. In 1975 there were five point sources of water pollution—including two sewage flow relief devices not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo only slight urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 9 and 11 percent of the total watershed area, respectively.

*Source: SEWRPC.*

Table 80

## LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE SAUK CREEK WATERSHED

| Water Quality Analysis Area as Presented on Map 29 | Location of Most Downstream Point Draining the Water Quality Analysis Area | |
|---|---|---|
| | Location | U. S. Public Land Survey Designation |
| | Sauk Creek | |
| 1 | Town of Belgium, east of CTH B | T12N, R22E, Section 20 |
| 2 | Town of Belgium, west of CTH KW | T12N, R22E, Section 21 |
| 3 | Town of Port Washington, west of STH 84 | T11N, R22E, Section 16 |
| 4 | City of Port Washington, south of STH 32 | T11N, R22E, Section 28 |

*Source: SEWRPC.*

Table 81

## REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE SAUK CREEK WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum | 50 | Minimum | Minimum |
| 2 | Minimum | 50 | Minimum | Minimum |
| 3 | Minimum | 50 | Minimum | Minimum |
| 4 | Minimum | 50 | Minimum | Minimum |

*Source: SEWRPC.*

Phosphate-Phosphorus: Sauk Creek will satisfy the phosphorus standard of 0.1 mg/l at least 90 percent of the time without diffuse source controls.

Un-ionized Ammonia-Nitrogen: Analyses of seasonal variations in estimated un-ionized ammonia-nitrogen levels in the Sauk Creek watershed indicate that the level of 0.02 mg/l should seldom be exceeded. Diffuse source controls should not be necessary to satisfy the un-ionized ammonia-nitrogen standard in the watershed.

Summary: Table 81 presents the general level of diffuse source pollutant loading reductions and bottom oxygen demand reductions necessary to satisfy the applicable water quality standards for the Sauk Creek watershed. Required reduction values are shown for each water quality analysis area and for each pollutant for which a standard has been recommended. In general, only a 50 percent reduction in diffuse source fecal coliform loadings is required in the watershed. All other water quality standards are met without diffuse source controls.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Sauk Creek watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 30 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 82 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

The pollution potential classification analysis for the Sauk Creek watershed indicated relatively little variation in urban pollution potential, with 95 percent of the analyzed urban area receiving a moderate rating. The

## Figures 134-137

### EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE SAUK CREEK WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL

Figure 134

WATER QUALITY ANALYSIS AREA 1

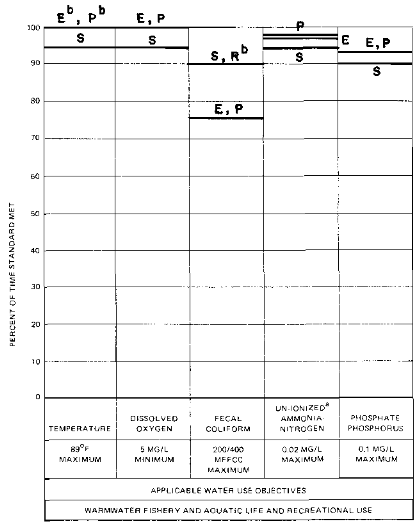



Figure 135

WATER QUALITY ANALYSIS AREA 2

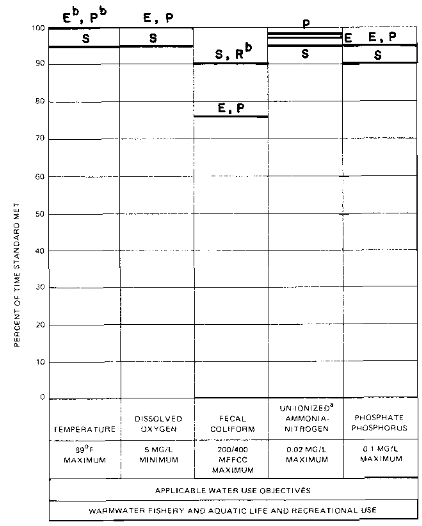



Figure 136

WATER QUALITY ANALYSIS AREA 3

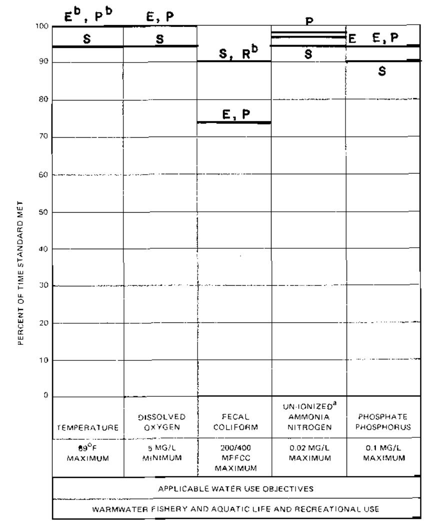
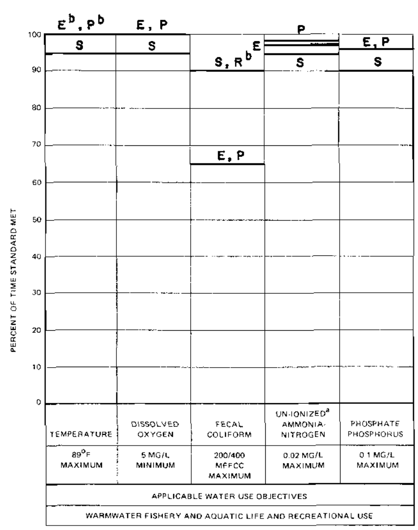



Figure 137

WATER QUALITY ANALYSIS AREA 4




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS.

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

R — MINIMUM ESTIMATED LEVEL ACHIEVABLE UNDER PLAN YEAR 2000 CONDITIONS BY IMPLEMENTING POLLUTANT RUNOFF CONTROLS DISCUSSED FOR THE WATERSHED.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

*Source: SEWRPC.*

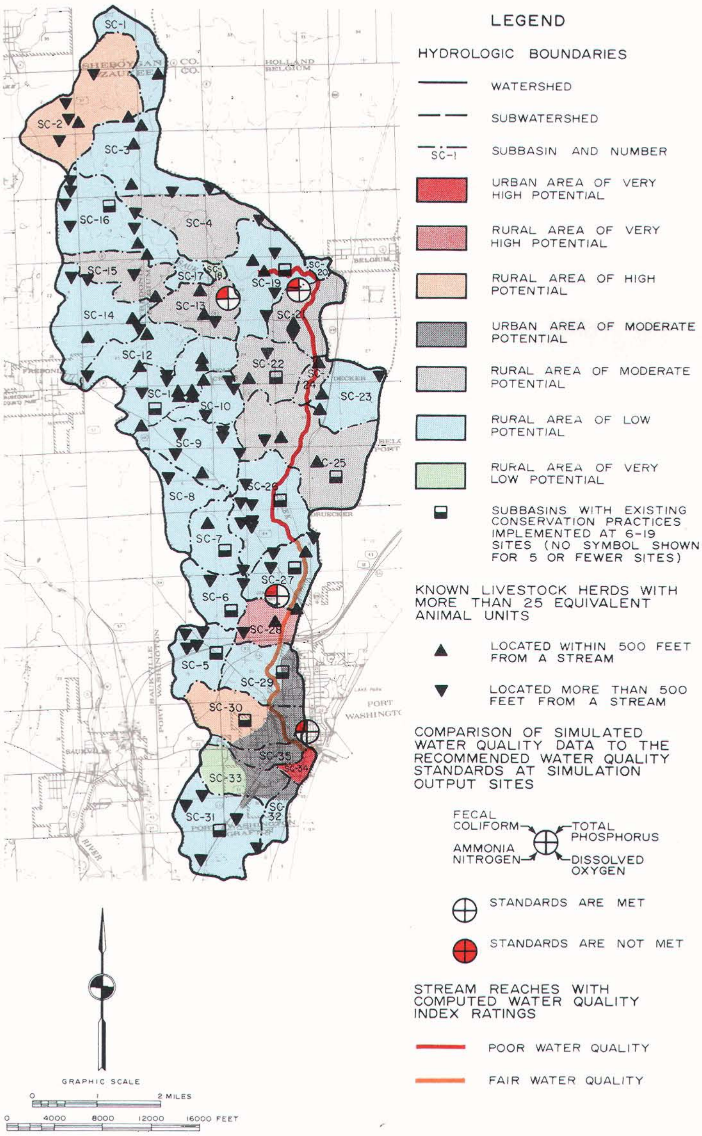
urban pollution potential analysis consisted of the portion of the City of Port Washington within the watershed. Eleven percent of the rural area is designated by a high or very high pollution potential rating, with 87 percent of the area being classified as having a low or moderate potential rating.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Sauk Creek watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protec-

Map 30

DIFFUSE SOURCE POLLUTION POTENTIAL IN THE SAUK CREEK WATERSHED




The hydrologic subbasins in the Sauk Creek watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the approximately 861 acres devoted to urban land uses in the watershed, 5 percent recorded a very high potential rating for nonpoint source pollution, with the remaining area recording a moderate rating. Of the 21,233 acres devoted to rural land uses in the watershed, 11 percent was estimated to have a high or very high potential, 23 percent a moderate potential, and the remaining 66 percent a low or very low potential for nonpoint source pollution. Thus, as of 1975, the Sauk Creek watershed exhibited a moderate potential for urban nonpoint source pollution and a moderate to low potential for rural nonpoint source pollution.

*Source: SEWRPC.*

tion, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of Sauk Creek. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding ponds, are needed to sufficiently reduce pollutant loadings from all animal operations. In addition, those animal operations located less than 500 feet from a stream and in high or very high pollution potential areas (see Map 30) require manure storage through the winter in a dry stacking system incorporating runoff control or in a liquid or slurry storage system, with no winter spreading of manure in order to avoid spreading on frozen ground and the attendant high rates of surface runoff. The control of livestock waste runoff is expected to sufficiently alleviate fecal coliform problems in the watershed.

Table 82

AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE SAUK CREEK WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | 44 | 5 | 375 | 2 | 419 | 2 |
| High . . . . . | -- | -- | 1,910 | 9 | 1,910 | 9 |
| Moderate. . . | 817 | 95 | 4,963 | 23 | 5,780 | 26 |
| Low. . . . . . | -- | -- | 13,581 | 64 | 13,581 | 61 |
| Very Low . . | -- | -- | 403 | 2 | 403 | 2 |
| Total | 861 | 100 | 21,233 | 100 | 22,094 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $1.5 million, of which $601,000, or 40 percent, would be for urban practices and $902,000, or 60 percent, would be for rural practices, and an average annual operation and maintenance cost of $105,000, of which $11,000, or 10 percent, would be for urban practices and $94,000, or 90 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 83.

## Sheboygan River Watershed

The water quality of the Sheboygan River and its major tributaries was simulated for 18 stream reaches and their associated subbasins, with the results reported and statistically analyzed for 4 simulation sites under existing conditions and under plan year 2000 conditions with various levels of pollution control. The location of these 4 simulation sites and the corresponding tributary water quality analysis areas are shown on Map 31 and presented in Table 84. The following discussion and Figures 138 through 141 present the percent of time the recommended water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, fecal coliform, and phosphorus are met under existing land use conditions as well as under year 2000 planned land use conditions with recommended point source controls. All streams in the Sheboygan River watershed within the Region are classified for warmwater fishery and aquatic life and recreational use.

Table 83

## ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE SAUK CREEK WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost: Total Capital (1975-2000) | Estimated Cost: Average Annual Operation and Maintenance |
|---|---|---|
| Urban | | |
| Septic System Management[a] . . . . . . . . . . | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] . . | Minimal | 7,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures . . . . . . . . . . . | 84,000 | Minimal |
| Construction Erosion Control Practices . . . . | 517,000 | 4,000 |
| Subtotal | $ 601,000 | $ 11,000 |
| Rural | | |
| Minimum Conservation Practices[c] . . . . . . . | 6,000 | 37,000 |
| Livestock Waste Control . . . . . . . . . . . . | 896,000 | 57,000 |
| Subtotal | $ 902,000 | $ 94,000 |
| Total | $1,503,000 | $105,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of Sauk Creek. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $398,000, and an average annual operation and maintenance cost of $12,000.*

[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

Table 84

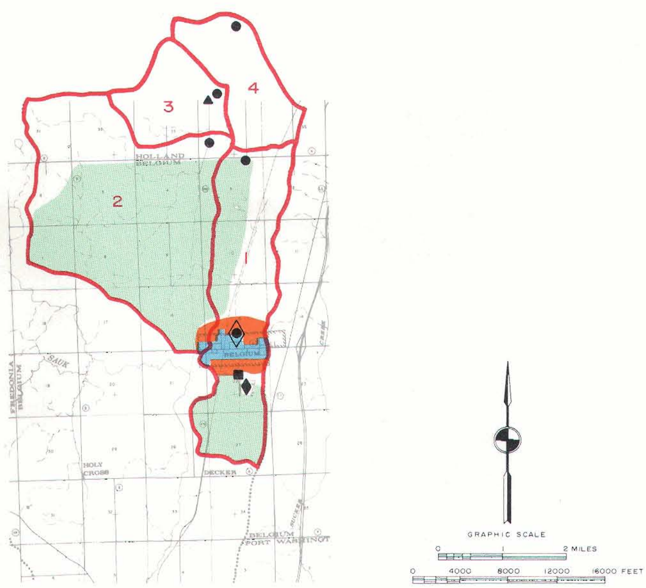
## LOCATION OF WATER QUALITY ANALYSIS AREAS IN THE SHEBOYGAN RIVER WATERSHED

| Water Quality Analysis Area as Presented on Map 31 | Location of Most Downstream Point Draining the Water Quality Analysis Area: Location | Location of Most Downstream Point Draining the Water Quality Analysis Area: U. S. Public Land Survey Designation |
|---|---|---|
| | Sheboygan County | |
| | Belgium Creek | |
| 1 | Town of Holland, north of CTH K | T13N, R21E, Section 34 |
| | Onion River | |
| 2 | Town of Holland, east of CTH KW | T13N, R21E, Section 34 |
| 3 | Town of Holland, north of CTH 144 | T13N, R21E, Section 27 |
| 4 | Town of Holland, north of CTH D | T13N, R21E, Section 22 |

*Source: SEWRPC.*

Map 31

## WATER QUALITY ANALYSIS AREAS IN THE SHEBOYGAN RIVER WATERSHED




LEGEND

WATER QUALITY SITES AND AREAS

- WATER QUALITY ANALYSIS AREA BOUNDARY AND NUMBER
- WATER QUALITY SIMULATION SITE
- WATER QUALITY SAMPLING STATION

SEWER SERVICE AREAS AND PRIMARY LAND USES

- EXISTING SEWER SERVICE AREA 1975 - SEPARATE
- PROPOSED INCREMENTAL SEWER SERVICE AREA 2000
- PRIME AGRICULTURAL LAND 2000
- OTHER RURAL LAND 2000

POINT SOURCES OF POLLUTION

- EXISTING PUBLIC SEWAGE TREATMENT PLANT TO BE RETAINED AND TO DISCHARGE EFFLUENT TO LAND
- EXISTING PRIVATE SEWAGE TREATMENT PLANT TO BE RETAINED
- KNOWN POINT SOURCE OF WASTEWATER OTHER THAN SEWAGE TREATMENT PLANT OR FLOW RELIEF DEVICES

The Sheboygan River watershed has an area of 11 square miles and ranks last in both size and in total resident population of the 12 watersheds in the Region. Within the Sheboygan River watershed there were 18 identified hydrologic subbasins grouped into four water quality analysis areas, each related to a water quality simulation output site. Also located within the watershed is one site for which water quality sampling data were obtained as part of Commission work programs. In 1975 there were four point sources of water pollution—including one sewage flow relief device not shown on this map—in the watershed which had to be considered in the water quality analyses along with the nonpoint sources. The watershed is expected to undergo only slight urbanization over the planning period, since the 1970 and plan year 2000 urban areas comprise 6 and 7 percent of the total watershed area, respectively.

*Source: SEWRPC.*

**Figures 138-141**

**EXPECTED WATER QUALITY STANDARD ACHIEVEMENT FOR WATER QUALITY ANALYSIS AREAS OF THE SHEBOYGAN RIVER WATERSHED FOR ALTERNATIVE LEVELS OF WATER POLLUTION CONTROL**

Figure 138

WATER QUALITY ANALYSIS AREA 1

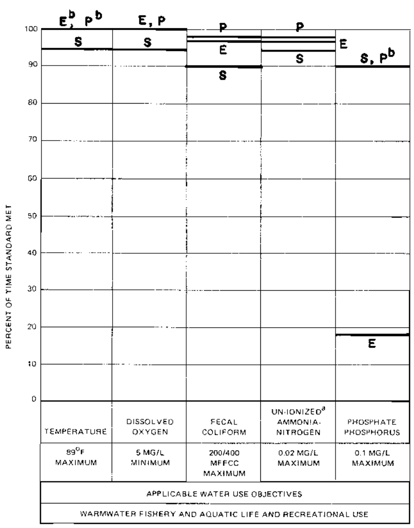



Figure 139

WATER QUALITY ANALYSIS AREA 2

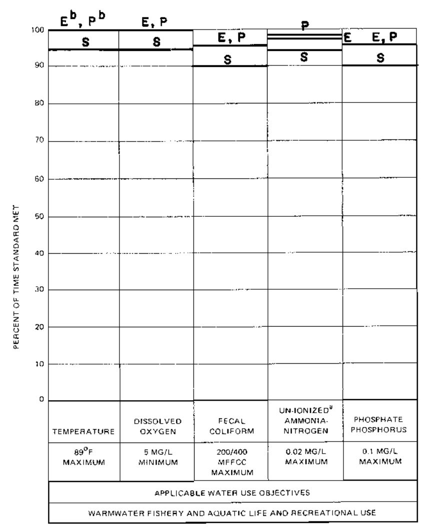



Figure 140

WATER QUALITY ANALYSIS AREA 3

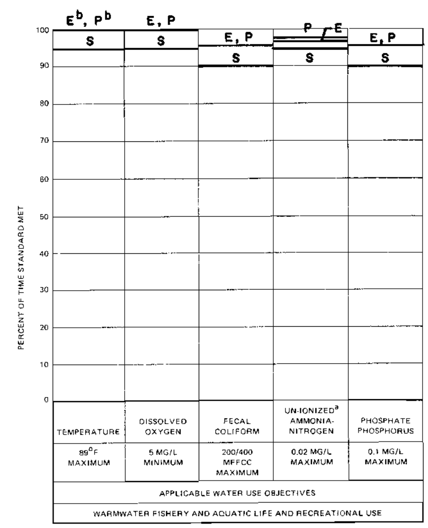
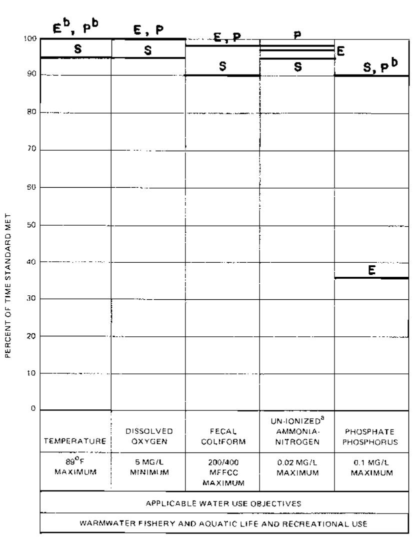



Figure 141

WATER QUALITY ANALYSIS AREA 4




LEGEND

S — MINIMUM ACHIEVEMENT LEVEL WITH POINT AND DIFFUSE SOURCE CONTROLS EXPECTED TO SATISFY WATER USE OBJECTIVES AND SUPPORTING WATER QUALITY STANDARDS

E — EXISTING LAND USE CONDITIONS AND POINT SOURCE CONTROLS.

P — YEAR 2000 LAND USE CONDITIONS WITH POINT SOURCE CONTROLS AND NO REDUCTION IN DIFFUSE SOURCE LOADS AND BENTHIC OXYGEN DEMAND.

[a] *THESE LEVELS REFLECT THE EXPECTED ACHIEVEMENT OF UN-IONIZED AMMONIA-NITROGEN LEVELS CONVERTED FROM SIMULATED TOTAL AMMONIA-NITROGEN LEVELS.*

[b] *THIS LEVEL IS ESTIMATED FROM AN INTERPRETATION OF FREQUENCY-DURATION CURVES FOR OTHER SIMULATED ALTERNATIVES.*

*Source: SEWRPC.*

As shown in Table 85, it is apparent from these figures that recreational use and warmwater fishery and aquatic life water use objectives and supporting water quality standards for temperature, dissolved oxygen, un-ionized ammonia-nitrogen, phosphorus, and fecal coliform are met under plan year 2000 land use conditions without the need for diffuse source loading reductions.

Identification of Pollution Priority Problem Areas: The hydrologic subbasins in the Sheboygan River watershed were classified according to selected criteria which indicate the existing potential of a subbasin to contribute diffuse source pollutants to surface waters. Map 32 indicates the areal extent of the various levels of diffuse source pollution potential in the watershed, and Table 86 summarizes the areal extent and relative proportions of the pollution potential classifications for urban and rural areas.

The pollution potential classification analysis for the Sheboygan River watershed indicated relatively little variation in urban pollution potential, with all analyzed

Table 85

## REQUIRED DIFFUSE SOURCE CONTROL LEVELS FOR WATER QUALITY ANALYSIS AREAS IN THE SHEBOYGAN RIVER WATERSHED

| Water Quality Analysis Area | Percent Diffuse Source Load Reduction Required | | | |
|---|---|---|---|---|
| | Dissolved Oxygen | Fecal Coliform | Un-ionized Ammonia-Nitrogen | Phosphorus |
| 1 | Minimum | Minimum | Minimum | Minimum |
| 2 | Minimum | Minimum | Minimum | Minimum |
| 3 | Minimum | Minimum | Minimum | Minimum |
| 4 | Minimum | Minimum | Minimum | Minimum |

*Source: SEWRPC.*

Table 86

## AREAL DISTRIBUTION OF DIFFUSE POLLUTION POTENTIAL CLASSIFICATIONS WITHIN THE SHEBOYGAN RIVER WATERSHED: 1975

| Pollution Potential Classification | Urban Areas[a] | | Rural Areas[a] | | Total Watershed | |
|---|---|---|---|---|---|---|
| | Area (acres) | Percent of Total Urban Area | Area (acres) | Percent of Total Rural Area | Area (acres) | Percent of Total Watershed Area |
| Very High . . | -- | -- | -- | -- | -- | -- |
| High . . . . . | -- | -- | -- | -- | -- | -- |
| Moderate. . . | -- | -- | 1,815 | 22 | 1,815 | 22 |
| Low. . . . . . | 71 | 49 | 6,254 | 78 | 6,325 | 77 |
| Very Low . . | 75 | 51 | -- | -- | 75 | 1 |
| Total | 146 | 100 | 8,069 | 100 | 8,215 | 100 |

[a] *The urban-rural designations represent the generalized land cover inventory results for the hydrologic subbasins.*

*Source: SEWRPC.*

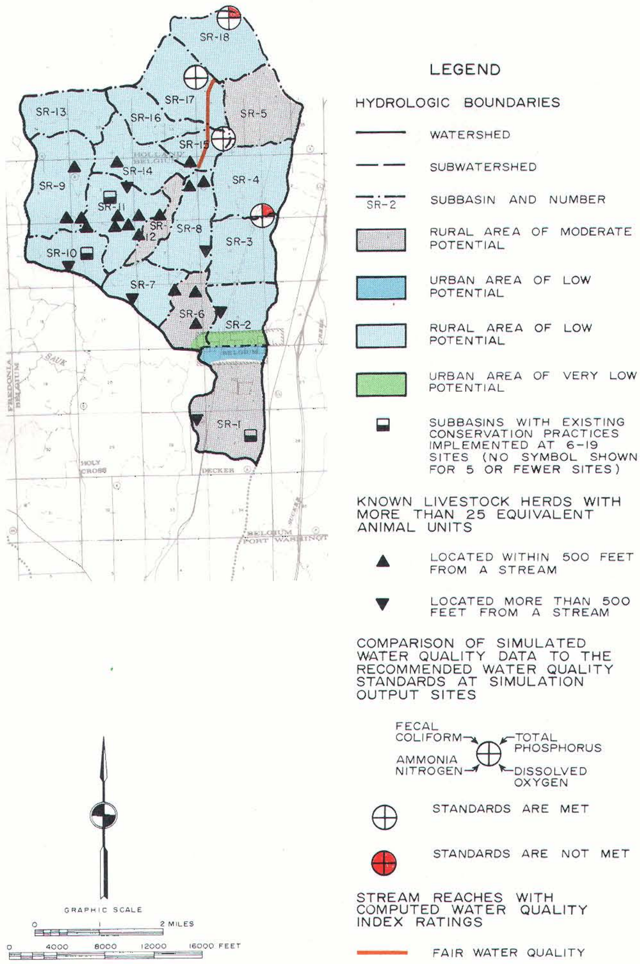
urban areas concentrated in the Village of Belgium receiving a low or very low rating. Twenty-two percent of the rural area is designated by a moderate pollution potential rating, and 78 percent of the area is classified as having a low potential rating.

Control of Pollutant Runoff from Urban Land: Minimum and low-cost urban diffuse source pollution control practices alone—such as public education programs; litter and pet waste control; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; proper use of fertilizers and pesticides; industrial and commercial material storage facilities and runoff control measures; and critical area protection—should provide a sufficient level of urban diffuse source pollution control in the Sheboygan River watershed. Construction erosion control practices and proper management of onsite sewage treatment systems will also be necessary for the abatement of diffuse source pollution.

Control of Pollutant Runoff from Rural Land: Minimum rural land management practices—inclusive of proper fertilizer and pesticide management, critical area protection, residue management, chisel tillage, pasture management, and contour plowing—should be implemented to protect the water quality of the Sheboygan River watershed. Animal waste runoff control systems, consisting of barn eaves troughs for storm water control, surface water diversions, settling basins, and holding ponds, are needed to control pollutant loadings from all animal operations.

Map 32

## DIFFUSE SOURCE POLLUTION POTENTIAL IN THE SHEBOYGAN RIVER WATERSHED




The hydrologic subbasins in the Sheboygan River watershed were classified according to selected criteria including land use, land characteristics, storm water drainage systems, waste treatment systems, and the age and condition of the housing stock, which were taken together as an indicator of the potential for nonpoint source pollution. Of the approximately 146 acres devoted to urban land uses in the watershed, about one-half recorded a low potential rating and about one-half recorded a very low potential rating for nonpoint source pollution. Of the approximately 8,069 acres devoted to rural land uses in the watershed, 78 percent was estimated to have a low potential for rural nonpoint source pollution, with the remaining 22 percent estimated to have a moderate potential. Thus, as of 1975, the Sheboygan River watershed exhibited a low potential for both urban and rural nonpoint source pollution.

*Source: SEWRPC.*

Cost Estimate: Implementation of the recommended diffuse source control plan would involve a total capital cost between 1975 and the year 2000 of $380,000, of which $246,000, or 65 percent, would be for urban practices and $134,000, or 35 percent, would be for rural practices, and an average annual operation and maintenance cost of $23,000, of which $3,000, or 13 percent, would be for urban practices and $20,000, or 87 percent, would be for rural practices. The cost estimates for each management practice are summarized in Table 87.

## LAKE WATER QUALITY ELEMENT

Existing and anticipated future water quality conditions, water pollution sources, and alternative pollution abatement measures for the 100 major lakes in the Region—that is, those lakes having a water surface area of at least 50 acres—were evaluated as part of the preparation of alternative areawide water quality management plans. The results of this evaluation are set forth in Appendix C to this volume for convenient reference.

Table 87

ESTIMATED COST OF DIFFUSE SOURCE POLLUTION CONTROL MEASURES FOR THE SHEBOYGAN RIVER WATERSHED

| Diffuse Source Pollution Control Measures | Estimated Cost | |
|---|---|---|
| | Total Capital (1975-2000) | Average Annual Operation and Maintenance |
| Urban | | |
| Septic System Management[a] | $ -- | $ -- |
| Low-Cost Urban Diffuse Source Controls[b] | Minimal | 1,000 |
| Industrial and Commercial Material Storage Facilities and Runoff Control Measures | 35,000 | Minimal |
| Construction Erosion Control Practices | 211,000 | 2,000 |
| Subtotal | $246,000 | $ 3,000 |
| Rural | | |
| Minimum Conservation Practices[c] | 2,000 | 11,000 |
| Livestock Waste Control | 132,000 | 9,000 |
| Subtotal | $134,000 | $20,000 |
| Total | $380,000 | $23,000 |

[a] *The proper maintenance and replacement of the remaining septic tank systems are recommended to help improve the water quality of the Sheboygan River watershed. However, because septic tank systems management is an existing function necessary for the preservation of public health and the protection of private drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management for the stream plan element include a capital cost over the period of 1975-2000 of $94,000, and an average annual operation and maintenance cost of $3,000.*

[b] *Low-cost urban controls include pet waste and litter control; fertilizer and pesticide use restrictions; public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; and critical area protection.*

[c] *Minimum conservation practices include crop residue management, chisel tillage, pasture management, contour plowing, fertilizer and pesticide management, and critical area protection.*

*Source: SEWRPC.*

## POINT SOURCE ELEMENT ALTERNATIVE PLANS

This section presents the results of the plan design, test, and evaluation phase of the areawide water quality management planning program in terms of alternative point source element plans for subareas of the seven-county Southeastern Wisconsin Region. As previously noted, alternative plans presented herein were developed utilizing the recommended point source plan elements of the regional sanitary sewerage system plan as a basis, with modifications as found to be necessary as a result of reevaluations conducted under the areawide water quality management planning program. These recommended elements have been updated to reflect the Commission's adopted year 2000 land use plan, new cost analysis bases, and changes which have occurred since the development of the regional sanitary sewerage system plan, as well as to reflect the findings of the water quality and pollutant loading analyses conducted under the areawide water quality management program. The recommended alternative plans and the detailed discussion of all alternative plans investigated in the development of the regional sanitary sewerage system plan are presented in detail in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.

The regional sanitary sewerage system plan concluded that the biological and physical-chemical sewage treatment processes currently in use may be expected to continue in use through the plan design period, although new technology will likely be introduced at some treatment facilities within the Region during the planning period. It also concluded that treatment plant effluent would continue to be discharged to natural surface waters or be disposed of on lands through either seepage ponds or irrigation processes. These conclusions have been reevaluated in the areawide water quality management planning program with regard to the state-of-the-art of studies documented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume One, Point Sources. The major emphasis of both the regional sanitary sewerage system plan and the point source element of the areawide water quality management planning program is placed on the basic alternative of providing advanced levels of waste treatment, including land application of effluent, at wastewater treatment locations throughout the Region and on alternative means of conveying wastewater to these locations. Other concepts of waste management, such as treatment and reuse, waste load reduction, alternative onsite or small-scale treatment systems, and diversion of wastewater treatment plant effluent from the Lake Michigan basin, were also considered.

### Diversion of Wastewater Treatment Plant Effluent from the Lake Michigan Basin

As part of the analysis conducted under the regional sanitary sewerage system plan, an alternative considering diversion of wastewater treatment plant effluent from the Lake Michigan basin watershed was evaluated. It was noted in the regional sanitary sewerage system plan that more than 90 percent of the wastewater treatment plant effluent generated in the Region was discharged either directly to Lake Michigan or to streams which drain into Lake Michigan. In 1975 about 267 million gallons per day (mgd), or 91 percent of the 293 mgd of wastewater treatment plant effluent discharged in the Region, were discharged either directly to Lake Michigan or to streams which drain into Lake Michigan. Thus, total diversion of treated effluent out of Lake Michigan would constitute a major undertaking. As noted in the regional sanitary sewerage system plan, the cost of diverting all treatment plant effluent out of Lake Michigan would almost totally be an "add on" cost to any of the alternative system plans considered. This is to say, conveyance facilities required to effect diversion would, in general, represent an additional cost above and beyond what would be needed to provide sanitary sewer service and adequate wastewater treatment if wastewater treatment plant effluent continued to be discharged either to Lake Michigan or to streams tributary to Lake Michigan.

The cost of providing treatment at the various facilities under the diversion alternative would approximate the cost of providing treatment under the treatment alternative with continued discharge to Lake Michigan, but would likely be somewhat higher since advanced waste treatment for nitrification would be required in most cases as well as advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. In addition, under the diversion alternative tertiary treatment would likely be required for reduction of five-day biochemical oxygen demand ($BOD_5$) below secondary levels because of the large volume of wastewater relative to the flow regimens of the receiving streams. Recommended levels for treatment facilities with discharges to Lake Michigan would probably include secondary treatment as well as advanced waste treatment for phosphorus removal. Because of special agreements between the State of Illinois and the Cities of Kenosha, Racine, and South Milwaukee, treatment facilities operated by those cities may need to include tertiary treatment units to achieve higher than secondary levels of treatment for $BOD_5$ and suspended solids. In addition, a stipulated agreement to a lawsuit brought by the State of Illinois against the City of Milwaukee, et al., may require the installation of tertiary facilities at the two major Milwaukee Sewerage Commissions treatment plants. Nevertheless, the cost of providing treatment under the diversion alternative may be expected to be equal to or greater than the cost of providing treatment and discharging effluent in the Lake Michigan basin.

One method of carrying out a diversion alternative was considered in the regional sanitary sewerage system plan and has been updated to reflect year 2000 conditions (see Map 33). Under that conceptual alternative, diversion would occur at five locations. One location would serve the existing communities in the Washington County portion of the upper Milwaukee River watershed. Trunk sewers would convey raw sewage from the Villages of Jackson, Kewaskum, and Newburg, and to the site of the existing West Bend wastewater treatment facility. The West Bend facility would be expanded to handle all of the anticipated demand, and a diversion outfall sewer would be constructed from the West Bend plant to the east branch of the Rock River at a point just north of the Allenton Sanitary District in the Town of Addison.

The second location would accommodate all sewage from existing communities in Ozaukee County except the Village of Thiensville and the City of Mequon, which would discharge to the Milwaukee metropolitan system. Major trunk sewers would be constructed to connect the Belgium-Lake Church, Fredonia, Saukville, Port Washington, and Grafton sewer service areas to a major sewage treatment facility located at or near the site of the existing City of Cedarburg facility. From there a diversion outfall sewer would be constructed westerly to a location on the Ashippun River, a tributary of the Rock River, in the Town of Erin.

The third location would accommodate all sewage from the Milwaukee metropolitan sewer service area. Major deep tunnel diversion outfall sewers would be constructed to connect the Jones Island and South Shore sewage treatment facilities operated by the Milwaukee-Metropolitan Sewerage Commissions. The City of South Milwaukee sewage treatment facility would be abandoned and its service area connected to the South Shore plant. All effluent would be discharged to the Wind Lake drainage canal, a tributary of the Fox River, just below Wind Lake.

The fourth location would accommodate all sewage from the Kenosha and Racine metropolitan areas as well as from the proposed Yorkville Sanitary District No. 1 service area. Deep tunnel diversion effluent sewers would be constructed to convey effluent from the Kenosha and Racine sewage treatment plants jointly to a point on the Des Plaines River in the Town of Paris.

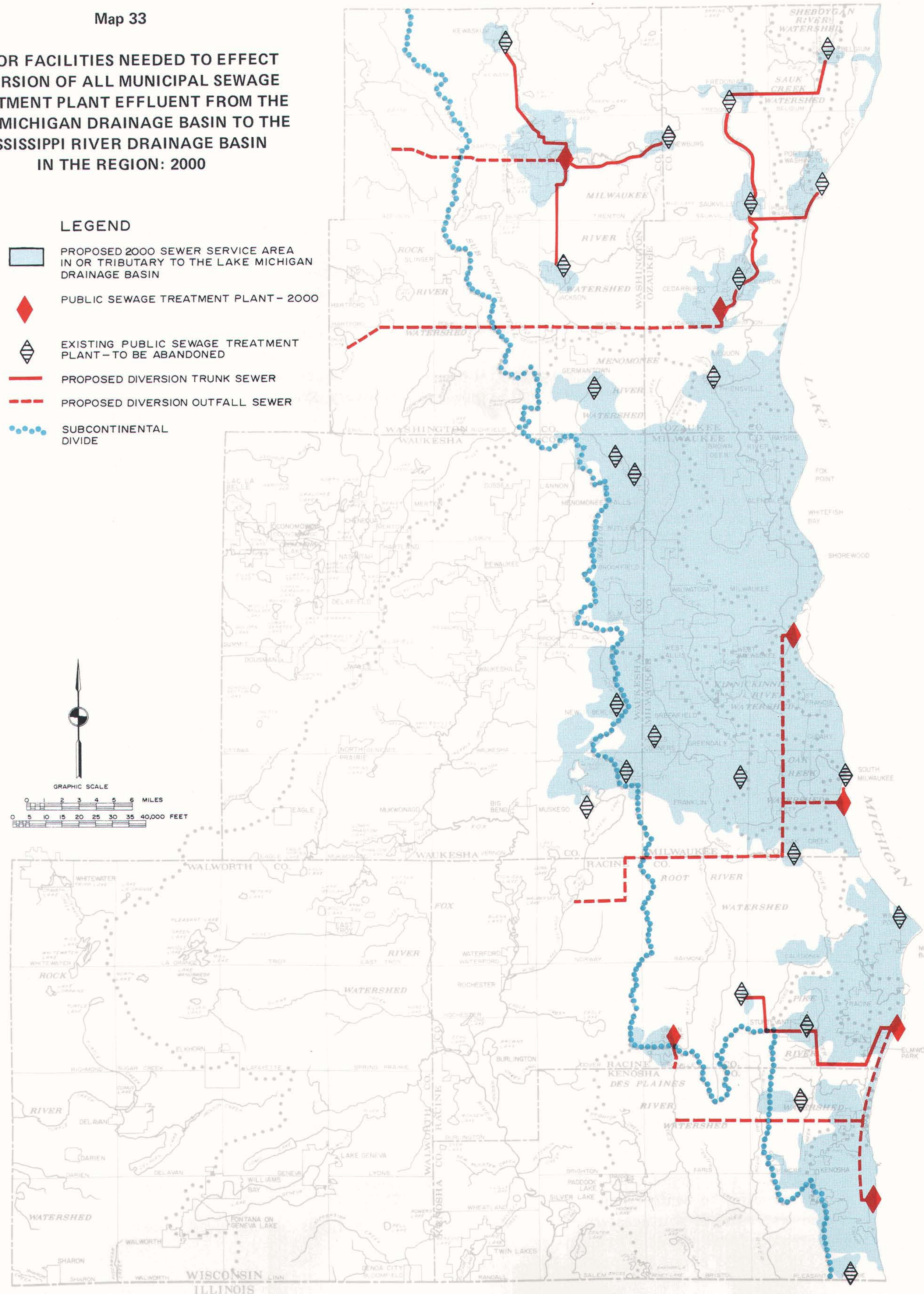
Finally, the fifth location would accommodate sewage flow from the Village of Union Grove and would consist of a minor diversion effluent sewer from the existing Union Grove sewage treatment facility across the subcontinental divide to the Des Plaines River in the Town of Paris.

A cost estimate for the major facilities required to accommodate large-scale diversion out of the Lake Michigan watershed was developed under the regional sanitary sewerage system plan. As documented in that plan, the present worth cost over a 50-year period for these facilities was about $151 million, with an equivalent annual cost of about $9,600,000. These costs were based upon January 1970 cost indices and would be expected to be significantly higher when utilizing updated cost indices.

The primary advantage of this alternative plan element would be the elimination of all discharges of treated sewage effluent to Lake Michigan, thereby reducing the potential for possible irreversible deterioration of the lake

Map 33

## MAJOR FACILITIES NEEDED TO EFFECT DIVERSION OF ALL MUNICIPAL SEWAGE TREATMENT PLANT EFFLUENT FROM THE LAKE MICHIGAN DRAINAGE BASIN TO THE MISSISSIPPI RIVER DRAINAGE BASIN IN THE REGION: 2000




The trunk and outfall sewers shown on the above map represent those conveyance facilities which would be required to fully effect diversion of all municipal sewage treatment plant effluent from the Lake Michigan drainage basin across the subcontinental divide to the Mississippi River drainage basin. The concept of total effluent diversion from the Lake Michigan drainage basin receives support from time to time because of concern over the possible irreversible deterioration of Lake Michigan from overfertilization attributable to the discharge of nutrients—particularly phosphorus—to the lake in sewage treatment plant effluent. This diversion scheme was prepared as an alternative under the regional sanitary sewerage system plan at the request of federal and state officials in order to provide an "order of magnitude" cost estimate for a Lake Michigan diversion alternative. It is important to note that the cost of diversion would comprise an "add on" cost in the sense that the cost of the diversion facilities required would be over and above those facilities included in the recommended areawide water quality management plan. Diversion of sewage effluent from the Lake Michigan basin should be undertaken only after very careful consideration and documentation of the need to exclude such effluent from Lake Michigan. Long-term effects of the continued discharge of treated effluent to Lake Michigan and, therefore, the need for diversion, can be established only on the basis of a water quality management study for the entire Lake Michigan basin.

due to eutrophication. Other attendant advantages would include low flow augmentation in the headwater areas of the Rock, Des Plaines, and Fox Rivers, which would receive the diverted effluent, and positive, although very minor if not negligible, effects upon high lake levels and attendant shoreline flooding and erosion problems in the Lake Michigan Basin.

The primary disadvantage of this alternative plan element would be the substantial additional cost entailed—a cost in addition to the costs attendant to other alternatives which would meet the established water use objectives. Other disadvantages include the potential contribution to flooding problems on the receiving streams, and the direct conflict of the proposal with present legal constraints which operate against any major diversion of surface water between the Lake Michigan and Mississippi River basins. These very complex legal constraints were more fully discussed in Volume One, Chapter VI of this report and would be very difficult to remove, involing, as they do, international as well as interstate considerations. Finally, the diversion alternative may have to be accompanied by even higher levels of treatment than indicated above because of the very limited waste assimilation capacities of the relatively small receiving streams.

Clearly, the diversion of all sewage effluent from the Lake Michigan basin to the Mississippi River basin would entail substantial additional costs and should be undertaken only after firm substantiation of the need to exclude such effluent from Lake Michigan. Long-term effects of the continued discharge of treated effluent to Lake Michigan and, therefore, the need for diversion can be established only on the basis of a basinwide water quality management study. Such a study lies beyond the jurisdictional responsibility of the Regional Planning Commission and should be undertaken by an agency like the Great Lakes Basin Commission, which has water resource planning responsibilities for the entire Great Lakes basin, as well as for the Lake Michigan basin. In this respect, it should be understood that the diversion alternative remains available to the Region at any future time with any of the alternative plans presented later in the chapter, and that costs required to implement the advanced waste treatment management concept, as set forth later in this chapter and in Volume Three, Chapter II of this report, would have to be incurred in any case to provide for wastewater collection, conveyance to, and treatment at central locations prior to diversion.

Waste Load Reduction Alternatives

Waste load reduction measures were evaluated under the areawide water quality management planning program as a means of contributing to water quality management goals. Domestic water use in southeastern Wisconsin has historically increased from about 67 gallons per capita per day (gpcd) in 1970 to about 89 gpcd in 1975.[14] This increasing water use requires increased wastewater treatment and conveyance capacity for proper treatment of the spent domestic wastewater.

Historically, sanitary engineering and public works activities have sought to treat all of the wastes which arrived at the lower end of a sewage collection system. Recently, however, increasing importance has been placed upon reducing the volume of waste to be treated. Examples of this emphasis include the sewer use ordinances of local units of government, regulatory agency concern for control of excessive infiltration and inflow within the collection systems, pretreatment of industrial wastewaters, and the user charge and industrial cost recovery systems which have been found to affect the amount of wastewater discharged to a collection system. Another potentially useful practice which may be expected to become of increasing importance as energy becomes more costly is the general reduction in water use and, therefore, of wastewater flows through modifications of plumbing fixtures and equipment.[15]

Reduction of wastewater flow and pollutants received at existing wastewater treatment plants would allow those plants to operate for a longer period of time at or below design conditions, providing increased treatment and eliminating or delaying the need for facility expansion. Lower flows and loads would also mean lower plant operation and maintenance costs.

There does exist the possibility of an undesirable effect from lower wastewater flows. Increased treatment would result in improved stream water quality. Flow reduction, however, may in some situations lower flows in receiving streams or cause odors within sewer systems due to lower flows and resultant solids buildup.

The Commission reviewed and evaluated the potential waste load reduction measures in terms of their cost and effectiveness. This analysis is documented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control for Southeastern Wisconsin, Volume One, Point Sources. Those methods and techniques identified as being implementable are intended to form the basis for the recommendation of waste load reduction programs. The state-of-the-art analyses indicates that a number of flow and waste load reduction measures appear to be applicable within the Region. The following paragraphs summarize the findings of the state-of-the-art studies regarding opportunities for flow and load reduction.

Sewer System Infiltration and Inflow Reductions: In recent years, reduction of infiltration and inflow wastewater flows has received considerable attention. Com-

[14] *See Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.*

[15] *The Wisconsin State Legislature, in Chapter 275 of the Laws of 1977, has mandated that all new household flow fixtures, including water closets, faucets, and shower heads but excluding kitchen fixtures, sold after 1978 shall be of a water conserving nature.*

muities are conducting studies to determine the amounts of excessive infiltration and inflow existing in their sewer systems to meet state and federal prerequisites for grants in support of system improvements. A commitment to eliminate excessive infiltration/inflow into sewers is required before federal grant monies can be made available to expand or construct municipal wastewater treatment facilities. Excessive infiltration/inflow is generally defined as that portion of the infiltration/inflow that can be economically eliminated from the sewer system by rehabilitation. The quantity of excessive infiltration/inflow is determined by a cost-effectiveness analysis which compares the cost of reducing the inflow to the cost of providing sewage conveyance and treatment for the increased flow. The cost-effectiveness analysis is conducted as a part of local facility planning studies.

Based upon infiltration/inflow analyses conducted under various local facilities planning efforts in the Region, the reported amount of infiltration and inflow which can be cost effectively eliminated varies from zero to more than 75 percent. A reduction of about 50 percent of the inflow and 30 percent of the infiltration was assumed to be the average flow reduction practicable within the Region as a result of implementation of infiltration/inflow removal programs.

Water Conservation: Public information programs may be helpful in improving consumer attitudes toward the use of water conservation practices and devices. Water-saving devices available for use in residential construction include flow-limiting valves for showers and faucets, faucet aerators, shallow-trap water closets, dual-flush water closets, and washing machine level controls. Water-saving devices for public facilities include controls on urinals with flush tanks and time-release or self-closing faucets. In addition, such measures as lowering pressures in the water distribution system, metering water usage, and charging for actual water used can result in a reduction in water usage. An estimate of the water use reduction which can be achieved by utilizing each of the above-mentioned devices is included in SEWRPC Technical Report No. 18. It is estimated that the use of these water-saving devices in aggregate could reduce a typical household's domestic water use from 92 gpcpd to about 62 gpcpd.

Equalization Basins: Flow equalization may allow use of smaller hydraulic units in a wastewater treatment facility, and may improve plant performance by eliminating large flow variations and reducing the variations in levels of raw wastewater constituents. Equalization basins to accomplish these purposes may be located in the sewage collection system or at the head end of a treatment facility. In some cases, the storage capacity of major trunk sewers can be used for flow equalization purposes. Consideration of the use of flow equalization basins is becoming more common in facility planning and designs. The basic concept involves storing maximum flow or loads for later release during periods of minimum flow or loads.

Water Reuse and Recycle: The reuse of wastewater generally requires that some form of treatment precede second or subsequent usage. Therefore, flow reduction to treatment facilities does not usually result from municipal reuse of wastewater. Reuse often requires more extensive treatment of wastes than that practiced without reuse. Water reuse and recycle are, however, more common industrial practices. Reuse involves using water more than once prior to discharge, while recycle systems recirculate the water continuously.

Industrial Load Reduction: Industries discharging wastes to a publicly owned treatment facility must pretreat those wastes which would interfere with the operation or performance of the treatment facility. In addition, under current federal regulations pretreatment standards based upon best practicable control technology currently available are required for all industries discharging to public sanitary sewerage systems after 1983.

Limited application of waste load reduction alternative measures has been assumed in the development of further alternative sanitary sewerage system plans. As noted earlier in this chapter, the design criteria utilized for estimating the flow-related components of sanitary sewerage systems assumed a reduction of about 20 percent in the existing average infiltration and inflow rates for the Region. In addition, it was assumed that the per capita domestic water use and the associated wastewater loading would not continue to increase in accordance with historic trends.

An analysis was also conducted to determine what effect water conservation measures implemented extensively throughout the Region would have on point source sanitary sewerage systems. The analysis was based upon an assumed reduction in the inflow component of the wastewater flow of 50 percent, a reduction in the infiltration component of 30 percent, and a reduction in the domestic wastewater component contribution of 30 percent. No reduction was assumed for the industrial and commercial contributions to wastewater flow. The analysis estimated the cost savings which could be achieved in the treatment facility and trunk sewer components of various size sewerage systems if the reductions in infiltration, inflow, and domestic water use noted above were achieved.

It was estimated that the reduction in infiltration, inflow, and domestic contribution components of wastewater flow would reduce the average design hydraulic loading to treatment facilities by about 25 percent. Assuming the need to provide secondary plus advanced waste treatment, an estimated cost savings of 9 to 14 percent would result from implementation of flow reduction for both the treatment facilities and trunk sewers, and annual operation and maintenance costs would be reduced by about 15 to 22 percent. This percent reduction only applies to the wastewater treatment-related portions of a sewage treatment plant and not to sludge-handling and disposal units, which were assumed to be unaffected by reductions in infiltration, inflow, and water use. Thus, the percent reduction in cost would be smaller if compared to the cost for the sludge-related facilities as well as the wastewater treatment facilities. Per capita savings in wastewater treatment and conveyance of from $6.00 to $14.00 per year could be expected, depending on the treatment facility size, if a high degree of wastewater load reduction is effected. This cost savings, as well as the general desirability of conservation practices, indicates that wasteload reduction alternatives are viable means of contributing to the water quality management goals in the Region.

The detailed analysis of benefits from waste flow reduction measures is specific to each community and requires detailed data which are collected and organized as part of the infiltration/inflow studies conducted under the local facilities planning program. Thus, the potential flow reduction alternatives can be considered in a manner analogous to alternatives involving the relative benefits of eliminating excessive flow as opposed to treatment and conveyance of that flow. For this reason waste load reduction alternatives for individual sewerage systems have not been analyzed specifically in the areawide water quality management planning program. It is recommended that this evaluation be conducted at the local facility planning level.

Treatment and Reuse Alternative

Wastewater reuse applications were evaluated under the areawide water quality management planning program as a means of contributing to water quality management goals. Those practices which appeared to have potential applicability for use in the Region were described in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control for Southeastern Wisconsin, Volume One, Point Sources. The alternative uses of renovated wastewater discussed in that report include municipal park and golf course watering; industrial cooling and boiler feed water; and agricultural uses—irrigation of crops and orchards, pastures, and forests.

Data are included in the state-of-the-art report on the expected treatment plant effluent quality of various processes as well as on the water quality requirements for various potential uses of the renovated effluent. Evaluation of alternatives involving reuse of wastewater must consider all the steps in the recycling process including the processing of the wastewater prior to reuse, the desired uses of the effluent, and the additional processing required prior to ultimate discharge to the environment—all considered within the broader framework of the hydrologic cycle in the Region.

The viability of effluent reuse or recycling plans will depend on a number of factors, including: the local uses of water which could potentially be considered for use of recycled effluent; the availability and cost of domestic, industrial, and irrigation waters from other sources; the cost of conveyance of the effluent to the site where it is to be reused or recycled; the quality of the effluent; requirements for the uses for which the effluent is to be considered; standards which must be met before discharge is permitted to local streams or for groundwater recharging; and public attitudes.

Recent publications[16] have documented the fact that there is an adequate supply of groundwater as well as an almost limitless supply of surface water available from Lake Michigan in the Region. Representative costs for municipal well water are reported in these publications to range from $0.70 to $0.82 per 1,000 gallons delivered to the user. Existing utilities utilizing Lake Michigan as a source of supply can generally deliver water to customers at less cost than can utilities which rely upon groundwater as a source of supply. Most of the major industrial centers and the large users of process and cooling water are located in the communities bordering Lake Michigan, and thus the major industrial users have a relatively inexpensive and reliable water source readily available. The cost associated with recycling water, including additional treatment and monitoring costs which may be required and the cost of transporting the wastewater effluent to the reuse location, would have to be compared with the costs of water from these domestic sources. Only when the costs become comparable would industrial or municipal reuse of renovated water become feasible. To date this has not generally been the case since the reuse of renovated wastewater is only practiced in isolated cases in the Region—mostly in the form of in-plant recycling of industrial waters. The costs of water in the Region and the technology of wastewater recycling are not expected to change dramatically enough during the planning period to significantly change the existing cost relationships between recycled wastewater and other more conventional sources. However, institution of user charge and industrial cost recovery systems is expected to encourage some recycling and reduction of waste discharge from industrial facilities.

More than 100 major lakes—lakes of 50 acres or more in size—and numerous smaller bodies of water and wetlands exist within the Region. Renovated wastewater is, therefore, not expected to be used significantly for the creation of lakes or wetlands during the planning period, since adequate recreational opportunities can be provided utilizing the existing natural surface water and wetland system of the Region.[17]

The hydrology of the Region is such that 70 to 75 percent of the average annual precipitation of about 30 inches leaves the Region as evapotranspiration, leaving 25 to 30 percent available for surface or groundwater supplies. Thus, the more arid conditions which may exist

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[16] *Consoer, Townsend, and Associates Engineering Report, Sources of Water Supply for Mequon, Brookfield, Bayside, River Hills, Thiensville, Menomonee Falls, and Germantown, Wisconsin, March 1976; SEWRPC Technical Record, Volume 4, No. 1, "Is There a Groundwater Shortage in Southeastern Wisconsin," by D. S. Cherkauer and V. W. Bacon; and SEWRPC Planning Report No. 26, A Comprehensive Plan for the Menomonee River Watershed, October 1976.*

[17] *See SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000.*

in some parts of the United States and make reuse of municipal wastewater effluent attractive do not exist in the Region.

Reuse for irrigation of agricultural lands may be expected to be the major use of renovated wastewater practicable within the Region. The present use of renovated wastewater for purposes other than irrigation are not expected to change significantly in the Region over the planning period of the areawide water quality management planning program. The use of municipal wastewater treatment plant effluent for agricultural irrigation, however, may be expected to be increasingly considered as a water quality management practice as described in the succeeding section of this chapter.

In view of the above discussion, the alternative plans described in this chapter emphasize providing needed levels of wastewater treatment either for discharge to the surface waters—referred to as the treatment and discharge alternative—or for land application systems—referred to as the land application alternative—while encouraging the practice of reuse or recycling of wastewaters where local facilities planning efforts show such practices to be practical.

Land Application Alternative

The concept of land disposal of wastewater effluent was considered in the regional sanitary sewerage system planning program. The study concluded that although land application is a viable method of effluent disposal, physical and economic constraints restrict its use within the Region to a small individual community scale—in particular, communities located in the more rural reaches of the Region. For such communities, land application was recommended to be considered by design engineers during plan implementation.

Further review of land application was considered warranted under the areawide water quality management planning program. This review was prompted by recommended changes in wastewater treatment level requirements for some communities, an increased emphasis on recycling of wastes, and refinement of land application methods. An analysis of the applicability, effectiveness, and economics of effluent land application was conducted under the review of the state-of-the-art of water pollution control as documented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume One, Point Sources.

For land application systems a wide range of design possibilities exists because of very site-sensitive design requirements. Design considerations include land availability, ownership, and use patterns, wastewater application characteristics, method of application, climate, topography, soils, geology, and vegetation.

For the systems level analyses, land application of disinfected secondary treatment plant effluent was assumed. While all of the most common methods of application—irrigation, overland flow, and infiltration/percolation—have been used in Wisconsin, irrigation was assumed. Since land should be irrigated only during the growing season, an equivalent of 23 weeks of application was assumed in the alternative analyses, with no wastewater assumed to be applied in November, December, January, February, March, and portions of April and October to avoid problems with frozen ground and excessively wet fields and to minimize interference with planting and harvesting operations. Sufficient storage to meet the requirements of this assumption was incorporated into the systems designs. The installation of underdrains to enhance the natural rate of subsurface drainage was not included in the land application system design assumptions. However, in certain locations within the Region, the installation of underdrains may be determined in detailed facilities plans to be a practical method of increasing hydraulic loadings in the application site, and thereby reducing the land requirements. An average loading rate of 46 inches per year was assumed as a typical maximum value practicable for the common soils of the Region and the assumed application water characteristics. It was recognized that it is not practical to assume that an additional 46 inches of water could be applied annually to agricultural land without disruption of existing practices. For this reason, changes in the institutional structure affecting wastewater management agencies and land application site managers were considered necessary to effective implementation of any effluent land application program. Two alternative institutional arrangements were considered. The first institutional arrangement would allow the treatment plant manager to have full operational control, through purchase, lease, or other arrangments, of the land application site. In this case, agricultural operations on the land application site would be ancillary to the effluent and disposal function. Under this type of arrangement, it is assumed that the wastewater treatment plant effluent application rate could approximate 46 inches per year provided a site covered by suitable soils was used.

An alternative arrangement between the wastewater management agency and the land application site manager would allow the application site to be operated principally for agricultural production, with the effluent being applied to enhance that production. In this case it would be necessary to reduce the design annual wastewater loading rate on the land surface since, because of crop selection and annual precipitation, 46 inches per year is normally more than is desirable for agricultural production. Under this alternative arrangement, the land application site would not need to be controlled through ownership or other arrangement. A larger land application site would, however, be required than under the first institutional arrangement noted above.

The systems level analysis has been developed assuming the first institutional arrangement noted above—that is, that direct operational control of the land application site would rest with the wastewater management agency. Accordingly, the cost of acquiring the application site was included in the total cost estimate.

Maps of the plan year 2000 land use conditions within the Region and of the depth to groundwater were utilized to make a preliminary selection of potential application sites near the wastewater treatment facility under consideration. In addition, the detailed soils maps for the selected potential sites were reviewed to determine if any limitations on spray irrigation exist for the sites.[18] Areas with severe limitations for irrigation were not considered suitable for effluent land application.

A generalized analysis was initially conducted under the areawide water quality management planning program to determine the viability of treatment and effluent land application as an alternative to treatment and discharge to the surface waters of the Region. This evaluation consisted of an economic analysis comparing the cost of treatment and effluent land application to the cost of treatment and discharge for plants of varying sizes and varying levels of treatment under the treatment and discharge alternative. The evaluation indicated that, in many instances, effluent land application did present a viable alternative to discharge of effluent to the surface waters.

The three following specific levels of treatment were considered for the treatment and discharge of wastewaters to the surface waters. These levels were then compared to the effluent land application alternative:

1. Secondary waste treatment plus auxiliary waste treatment for effluent disinfection.

2. Secondary waste treatment plus conventional advanced waste treatment for nitrification—to a level of 1.5 mg/l of ammonia-nitrogen in the summer months—and phosphorus removal—to a level of 1.0 mg/l of total phosphorus—plus auxiliary waste treatment for effluent aeration and disinfection. This level was also considered without the component of advanced waste treatment for nitrification.

3. Secondary waste treatment plus a conventional level of advanced waste treatment for nitrification—to level of 1.5 mg/l of ammonia-nitrogen in the summer months—and a high level of advanced waste treatment for phosphorus removal—to a level of 0.1 mg/l of total phosphorus—plus auxiliary waste treatment for effluent aeration and disinfection. This level was also considered without the component of advanced waste treatment for nitrification.

In addition to the cost comparison, there are other less tangible, but nevertheless real factors which should be considered when comparing the treatment and effluent land application alternative to the treatment and discharge alternative. The ultimate implementation of the treatment and surface water discharge alternative is more likely to be readily accomplished since planning for a major portion of the plant components of the alternative may in some cases be complete. In addition, this alternative represents a continuation of existing practices with the added construction and operational requirements associated with any recommended expansion or upgraded level of treatment. Because of the land requirements for the land application system, it may be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus the land application alternative may be difficult to implement. The land application alternative requires the commitment of approximately 400 acres of land per million gallons per day of planned average hydraulic capacity, which would result in a change in agricultural land management for the selected application site area, and would require the treatment plant managers to become involved in agricultural land management. The land application alternative generally requires the construction of a major conveyance system in order to transport the treatment plant effluent to the land application site. Because of the direct and indirect environmental impacts of the proposed land use changes and the proposed construction project for the conveyance system under the land application alternative, this alternative would affect more area and a greater population than would the treatment and discharge alternative. On the other hand, although there would be a greater wastewater pumping requirement under the land application alternative for conveyance of the wastewater to the land application site, the total energy requirements associated with that alternative would generally be less than under the treatment and discharge alternative because of the energy required for the higher level of treatment normally needed prior to discharge to the surface waters. Other advantages of the land application alternative are that nutrients would be recycled from the wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be eliminated from the surface waters assuming proper design and operation of the facility.

The findings and recommendations of the general systems level evaluation with respect to further consideration of land application of effluent are summarized in Table 88. These generalized findings were supplemented by more site-specific analyses conducted under the areawide water quality management planning program for the larger facilities in the Region and by the findings of local facility planning studies when available.

The evaluation indicated that land application is generally more costly for all plant sizes when only secondary waste treatment followed by auxiliary waste treatment is required under the treatment and discharge alternative. For larger facilities the land application alternative was also indicated to be more costly than the provision of secondary waste treatment plus advanced waste treatment for phosphorus removal and auxiliary waste treatment. In each of these cases, the treatment and discharge alternative was recommended under the areawide water quality management planning program.

[18] *Limitations of soils for irrigation used are defined in SEWRPC Planning Report No. 8, Soils of Southeastern Wisconsin, June 1966.*

Table 88

SUMMARY OF EFFLUENT LAND APPLICATION GENERALIZED ANALYSIS FINDINGS AND RECOMMENDATIONS

| Facility Hydraulic Capacity and Treatment Level Requirements Under the Treatment and Discharge Alternative | Performance Standards in Terms of Effluent Quality Under the Treatment and Discharge Alternative (all standards represent average monthly limits) | Generalized Cost Analysis Findings[a] | General Recommendations for Further Alternative Evaluation |
|---|---|---|---|
| Average Hydraulic Capacity up to 1.0 mgd<br>Secondary waste treatment plus auxiliary waste treatment for effluent disinfection | $BOD_5$: 15 mg/l<br>Fecal Coliform: 200/100 ml | The treatment and effluent land application alternative is generally more costly than the treatment and discharge alternative | No further consideration of the effluent land application alternative is recommended |
| Secondary waste treatment plus a conventional level of advanced waste treatment for phosphorus removal plus auxiliarry waste treatment for effluent aeration and disinfection | $BOD_5$: 15 mg/l<br>Total Phosphorus: 1.0 mg/l<br>Dissolved Oxygen: 6.0 mg/l<br>Fecal Coliform: 200/100 ml | The treatment and effluent land application alternative is generally comparable—within 15 to 20 percent—in cost to the treatment and discharge alternative | Treatment and effluent land application is recommended initially under the areawide water quality management plan for plants with a hydraulic design capacity up to 0.5 mgd. More detailed analyses are to be conducted under the areawide plan for plants with a hydraulic design capacity between 0.5 mg/l and 1.0 mgd with further alternative evaluation to be conducted at the local facility planning level |
| Secondary waste treatment plus a conventional level of advanced waste treatment for nitrification and phosphorus removal plus auxiliary waste treatment for effluent aeration and disinfection | $BOD_5$: 15 mg/l<br>Ammonia-Nitrogen: 1.5 mg/l<br>Total Phosphorus: 1.0 mg/l<br>Dissolved Oxygen: 6.0 mg/l<br>Fecal Coliform: 200/100 ml | The treatment and effluent land application alternative is generally comparable—within 15 percent—in cost to the treatment and discharge alternative | Treatment and effluent land application is recommended initially under the areawide water quality management plan with further alternative evaluation to be conducted at the local facility planning level |
| Secondary waste treatment plus a conventional level of advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection | $BOD_5$: 0.15 mg/l<br>Ammonia-Nitrogen: 1.5 mg/l<br>Total Phosphorus: 0.1 mg/l<br>Dissolved Oxygen: 6.0 mg/l<br>Fecal Coliform: 200/100 ml | The treatment and effluent land application is generally less costly than the treatment and discharge alternative | Treatment and effluent land application is recommended initially under the areawide water quality management plan with further alternative evaluation to be conducted at the local facility planning level |
| Average Hydraulic Capacity over 1.0 mgd<br>Secondary waste treatment plus auxiliary waste treatment for effluent disinfection | $BOD_5$: 15 mg/l<br>Fecal Coliform: 200/100 ml | The treatment and effluent land application alternative is generally more costly than the treatment and discharge alternative | No further consideration of the effluent land application alternative is recommended |
| Secondary waste treatment plus a conventional level of waste treatment for phosphorus removal plus auxiliary waste treatment for effluent aeration and disinfection | $BOD_5$: 15 mg/l<br>Total Phosphorus: 1.0 mg/l<br>Dissolved Oxygen: 6.0 mg/l<br>Fecal Coliform: 200/100 ml | The treatment and effluent land application alternative is generally at least 15 percent more costly than the treatment and discharge alternative | Treatment and discharge to surface waters is recommended, with the treatment and effluent land application alternative to be examined in detail at the local facility planning level only if local conditions indicate land application may be viable |
| Secondary waste treatment plus a conventional level of advanced waste treatment for nitrification and phosphorus removal plus auxiliary waste treatment for effluent aeration and disinfection | $BOD_5$: 15 mg/l<br>Ammonia-Nitrogen: 1.5 mg/l<br>Total PHosphorus: 1.0 mg/l<br>Dissolved Oxygen: 6.0 mg/l<br>Fecal Coliform: 200/100 ml | Alternative costs are variable and further, more specific analyses are needed for cost comparison | Alternatives are to be analyzed further under the areawide water quality management plan and at the local facility planning level |
| Secondary waste treatment plus a conventional level of advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection | $BOD_5$: 15 mg/l<br>Ammonia-Nitrogen: 1.5 mg/l<br>Total Phosphorus: 0.1 mg/l<br>Dissolved Oxygen: 6.0 mg/l<br>Fecal Coliform: 200/100 ml | Alternative costs are variable and further, more specific analyses are needed for cost comparison | Alternatives are to be analyzed further under the areawide water quality management planning program and at the local facility planning level |

[a] *Cost information is included in SEWRPC Study Volume No. 1100-3, Memo Number 151.*

*Source: SEWRPC.*

The evaluation further indicated that land application is a viable alternative where the level of treatment required is higher than that which can be achieved utilizing conventional advanced wastewater treatment facilities for phosphorus removal. Thus, whenever a wastewater treatment plant effluent having less than 1.0 mg/l of phosphorus is required to achieve water use objectives under a treatment and discharge alternative, treatment and land application should be further considered as an alternative. In this case, therefore, the land application alternative is recommended under the areawide water quality management planning program, with a further recommendation that the treatment and discharge alternative be evaluated further at the local facility planning level for treatment facilities with hydraulic capacities of 1.0 mgd or less. For larger treatment facilities, further, more specific analysis of the two alternatives would be needed since more site-specific considerations may be apparent even at the regional analysis level which could influence the selection of alternatives for the larger facilities.

Finally, the analyses indicated that, for treatment plants with a hydraulic capacity of up to about 1.0 mgd that provide secondary treatment and conventional advanced waste treatment for phosphorus removal and nitrification with effluent concentrations of 1.0 mg/l of total phosphorus and 1.5 mg/l of ammonia, the annual cost of treatment and subsequent land application of the effluent may be expected to range from the same as that for the treatment and discharge alternative to 15 percent higher than the cost of that alternative. This cost difference can be a significant but not an overriding factor when compared to other site-specific considerations which must also be evaluated in subsequent facilities planning efforts, particularly with regard to the effluent land application alternative. Because site-specific conditions could determine the ultimate practicality of effluent land application, it is recommended that both the treatment and discharge alternative and the treatment with effluent land application alternative be further examined at the local facility planning stage. The cost analyses and the recommendations of the areawide water quality management planning program have been based upon the treatment and effluent land application alternative, but the plan recognizes the need for the more localized examination. When the hydraulic capacity of the treatment facilities significantly exceeds 1.0 mgd, further, more specific considerations may be apparent which could influence the selection of alternatives for the larger facilities.

The cost analyses assumed a secondary level of treatment producing an effluent concentration of 30 mg/l of five-day biochemical oxygen demand ($BOD_5$) as well as auxiliary waste treatment for effluent disinfection prior to discharge to an effluent land application system. Present state regulations as set forth in Chapter NR 214 of the Department of Natural Resources regulations provide for an effluent $BOD_5$ concentration of up to 50 mg/l prior to land application. In certain instances, design considerations at the local level may allow for this maximum $BOD_5$ concentration as a potential means of reducing the cost of the land application alternative. However, in the systems level analyses, an effluent concentration of 30 mg/l of $BOD_5$ was assumed.

Onsite Wastewater Disposal Alternatives

Onsite treatment and disposal is a potentially viable means of wastewater treatment for isolated enclaves of urban development. Federal facility planning guidelines require the evaluation of onsite treatment and disposal as an alternative to providing centralized sanitary sewer service to unsewered areas. This emphasis on onsite wastewater disposal is due, in part, to the concern over the possible secondary impacts, such as unplanned urban land use development, of providing sanitary sewers in the absence of adequate areawide and local planning and land use controls. Accordingly, onsite wastewater treatment and disposal was considered as a wastewater management alternative under the areawide water quality management planning program.

There are numerous onsite, or nonsewered, wastewater treatment and disposal systems available. Several of these systems were considered under the review of the state-of-the-art of water pollution control as documented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume One, Point Sources, and a partial listing of the available systems is set forth in Table 89.

In 1975 approximately 246,000 persons, or about 14 percent of the resident population of the Region, were served by onsite sewage disposal systems. These systems consisted of approximately 351 known holding tanks, 44 known mound-type septic tank systems, and 68,600 known conventional septic tank systems. Of the 85 public sanitary sewerage service areas proposed within the Region by the year 2000 under the adopted regional land use plan, all but 22 had sewer systems either in existence or under construction as of 1978. The remaining 22 sewer systems are recommended to be developed within the Region by the design year of the plan, along with five new sewage treatment plants.

Analysis of detailed soil survey data indicates that much of the Region is covered by soils that have severe or very severe limitations for urban development utilizing onsite sewage disposal systems. As shown on Map 22 in Volume One, Chapter III of this report, approximately 1,637 square miles, or about 61 percent of the total area of the Region, are covered by soils which are poorly suited for residential development without public sanitary sewer service on lots smaller than one acre in size. As shown on Map 23 in Volume One, Chapter III of this report, approximately 1,181 square miles, or about 44 percent of the total area of the Region, are covered by soils poorly suited for residential development without public sanitary sewer service on lots one acre or larger in size. It should be noted that the use of suitability ratings accompanying the detailed soil maps are empirical, being based upon the actual performance of the mapped soils for the specified uses as well as upon the characteristics

Table 89

ONSITE AND SMALL-SCALE WASTEWATER TREATMENT SYSTEM SUMMARY

| Type of System | Principle of Operation | Regulatory Status[a] | Available Cost Data | Remarks |
|---|---|---|---|---|
| Conventional Septic Tank and Soil Absorption Systems | Wastewater is settled and allowed to decompose anaerobically on the bottom of the septic tank. The clear liquid on top is allowed to flow by gravity or is pumped to seepage beds or trenches for infiltration percolation through the soil | Must be approved by the Wisconsin Department of Health and Social Services and meet all specified criteria. This is the most common method of onsite wastewater disposal | Capital: $1,100-$2,500<br>Operation and Maintenance: $30 per year | -- |
| Mound-Type Septic Systems | Same as conventional septic tank except that the soil absorption is built above ground with suitable materials to overcome site limitations (slowly permeable soils, shallow bedrock, and high groundwater) | Presently in a trial regulatory program status. All permits in Wisconsin have been used and no more will be issued until:<br>1) The Environmental Impact Statement is completed and presented at a public hearing, and the Wisconsin Department of Health and Social Services approves the system; or<br>2) the State Legislature gives the Department authority to approve the system over a five-year trial basis | Capital: $2,400-$4,500<br>Operation and Maintenance: $45 per year | -- |
| Incinerator Toilets | The system burns the soild wastes and evaporates liquid, leaving only sterile ashes | The Wisconsin Department of Health and Social Services has no objections to the use of these systems | Capital: $750-$1,000 (does not include the cost of gray water system) | Odor problems can exist, and the system must be combined with a system for treating gray water |
| Chemical Recirculation Toilets | A chemical fluid substitutes water as the flushing medium, and the solids are separated from fluid in a holding tank. The fluid is purified and recycled for further use | Not permitted by the Wisconsin Department of Health and Social Services unless manufacturer has proof of testing, ensures correct operation, and meets all standards of National Sanitation Foundation | Capital: $3,000-$4,500 (does not include the cost of gray water system) | Must be combined with a system for treating gray water |
| Composting Toilets | Composting toilets utilize chambers equipped with air ducts to decompose human and kitchen wastes | The Wisconsin Department of Health and Social Services has stringent criteria relative to the use of composting toilets | Capital: $850-$1,700 (does not include the cost of gray water system) | Must be combined with a system for treating gray water |
| Holding Tanks | Wastewater sewage is conveyed by liquid and is stored in a holding tank until it is removed and transported for treatment elsewhere. This method replaces sanitary sewer systems with tank trucks as the mode of transportation of sewage | There are no laws prohibiting the use of holding tanks, but the Wisconsin Department of Natural Resources has negative feelings toward the use of tanks, due primarily to improper operation. The Wisconsin Administrative Code requires a signed agreement between the local government and the owner which guarantees the pumping and transporting of the holding tank contents | Capital: $1,300-$3,000<br>Operation and Maintenance: $600-$1,800 per year | -- |
| Aerobic Treatment Units | Wastewater is settled and mixed with micro-organisms and then wastewater is resettled. The supernatant is discharged to a soil absorption system | The Wisconsin Department of Health and Social Services requires that aerobic units meet the same criteria as septic tanks. No surface disposal of effluent is permitted | Capital: $1,000-$2,000<br>Operation and Maintenance: $80-$135 per year (does not include soil absorption field or filtration and disinfection) | -- |
| Gray Water Treatment Systems | Gray water is pumped through two columns—calcite limestone and activated carbon—and is recycled to the user's system for reuse | This system has been accepted by the Wisconsin Department of Health and Social Services on an experimental basis, and is still awaiting final clearance from the National Sanitation Foundation | Capital: $3,000-$4,000<br>Operation and Maintenance: $100-$120 per year for electricity plus costs for maintaining calcite and activated carbon | -- |

[a] *Local regulations are also applicable in most areas of southeastern Wisconsin.*

*Source: Donohue & Associates, Inc., Stanley Consultants, Inc., and SEWRPC.*

of the soils such as high water table, slow permeability, high shrink-swell potential, low bearing capacity, frost heave, steep slopes, and frequent flooding.

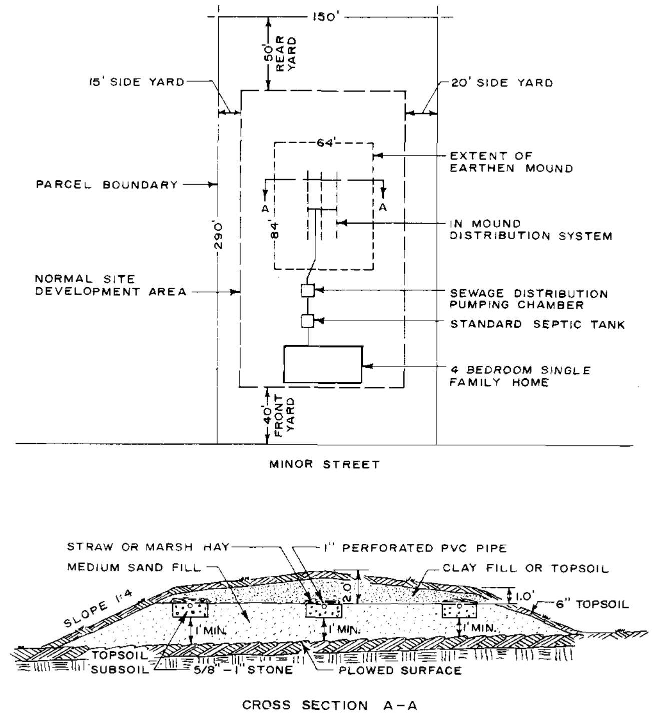
In May 1975, the Wisconsin Department of Health and Social Services, Division of Health, approved for use throughout Wisconsin three new types of "package" onsite soil absorption sewage disposal systems designed to overcome certain soil limitations such as impermeability, high groundwater, and shallow bedrock. These new package systems, which represent the first in a proposed series of such systems, were developed by the Division of Health and the University of Wisconsin after extensive research studies and in direct response to problems of groundwater contamination caused by malfunctioning septic tank systems throughout the State, but most notoriously concentrated in Door County, where similar bedrock conditions are prevalent.

Unlike the conventional gravity flow septic tank system, these new systems utilize mechanical facilities to pump septic tank effluent through small-diameter perforated distribution pipes placed in fill on top of the natural soil. When in place, this fill takes on the appearance of a mound; hence, the new systems are commonly called "mound systems." Figures 142 illustrates the placement of a mound system on a one-acre single-family residential parcel. In this typical installation, which is assumed to be designed to accommodate wastes from a four-bedroom single-family home, the mound would approximate an area 64 feet wide by 84 feet long, or 5,376 square feet—about 12 percent of the total area of the lot. At its highest point, the mound would be approximately five feet in height. Because of the relatively large size of the mound and the need to reserve sufficient area for a replacement mound at some future date, the residential parcels on which such systems are to be placed should be at least one acre in area. As shown in Figure 142, the mound system continues to utilize a standard septic tank, while adding a sewage distribution pumping chamber. The pump located in this chamber functions much like a sump pump, and provides daily dosing of the septic tank effluent into the mound system. The mound itself is constructed with sand fill covered by layers of clay and topsoil. The septic tank effluent distribution pipes are placed in crushed stone trenches covered with straw or marsh hay.

The first of the three systems recently approved for use is designed to be constructed on slowly permeable soils having seasonally high water tables. Under the rule adopted by the Division of Health, this package may be used at the present time only to solve problems on existing developed parcels. The second and third packages are designed to overcome problems both with respect to existing and future development in those areas where soils are naturally permeable but where shallow creviced bedrock, in the case of package two, or high water tables, in the case of package three, exist. The use of any of the package systems must be approved by the Division of Health on a case-by-case basis, and is also subject to approval by the local units of government. All such systems must be monitored, with the monitoring results reported directly to the Division of Health.

**Figure 142**

**MOUND-TYPE ONSITE SOIL ABSORPTION SYSTEM**




As shown in the accompanying sketch, the mound system continues to utilize a standard septic tank, while adding a sewage distribution pumping chamber. The pump located in this chamber would function much like a sump pump, and would provide daily dosing of the septic tank effluent into the mound system. The mound itself would be constructed with sand fill covered by layers of clay and topsoil. The septic tank effluent distribution pipes would be placed in crushed stone trenches covered with straw or marsh hay.

*Source: SEWRPC.*

While the rules adopted by the Division of Health currently restrict the applicability of the mound systems, all restrictions relating to such use would probably be lifted in the future if the systems prove to be operational on a widespread basis. Similarly, it is highly likely that the additional package systems to be developed will be designed to overcome nearly all natural soil limitations that currently inhibit or restrict the utilization of onsite sewage disposal systems. The net result of these developments would be to remove soil limitations for onsite sewage disposal as a constraint on regional settlement patterns, and thereby permit substantial additional areas to be developed for urban use without centralized sanitary sewerage systems, thus encouraging further diffusion of urban development throughout the Region in a wasteful, environmentally unsound pattern, destructive of both older urban centers and the natural resource base. Map 23 in Volume One, Chapter III of this report identifies that area of the Region which could be subject to urban development with mound-type septic tank systems if the current restrictions on the application of such systems are lifted and the additional package systems now being developed are introduced. This area amounts to approximately 465 square miles, or about 17 percent of the area of the Region. In effect, only those soils currently unsuitable even for residential development with public sanitary sewer service would remain unsuitable for development.

The adopted regional land use plan was the basis for the delineation of the areas to be served by the expansion of existing sanitary sewer systems in the Region, or by the development of new systems. The sewer service area delineations were based upon careful consideration of, among other factors: topography, soil suitability, drainage, population and economic activity levels, local proposals for sewer service, desirable urban development densities, land use, transportation and public utility configurations, and developable land and housing needs.

Those sewer service areas which are delineated under the areawide water quality management plan include about 634 square miles, or 24 percent of the total area of the Region, with a year 2000 forecast resident population of 2,080,000, or about 94 percent of the forecast year 2000 regional population. An analysis was conducted, as described in the following section, to determine for selected areas the potential desirability of providing public sanitary sewer service, or of continuing to rely on onsite waste disposal systems. These areas generally included enclaves of urban development located outside the initially proposed year 2000 sewer service areas. The use of onsite systems is an effective wastewater treatment technique suitable for use in many such areas. The potential problems of groundwater and surface water pollution which can be associated with onsite wastewater treatment systems generally are of greatest concern in areas with existing or proposed development on soils which are indicated to be unsuitable for onsite waste disposal. The potential for pollution is more severe in the areas developed to a higher density, although even a small number of malfunctioning systems could be the cause of problems if sited improperly with regard to groundwater supply wells. For purposes of the areawide planning analysis, areas with a density of 32 housing units per quarter section, or an average of one housing unit per five gross acres, were considered. The analysis conducted for these selected areas was based upon an evaluation of the soil suitability, lot size, suitable onsite waste disposal systems, population, and distance from nearest public sewer service area in relation to the cost of connection to a sewer service area and the cost of onsite waste disposal.

Two categories of recommendation were developed as a result of this general economic analysis. The areas which fall into each category are noted in the following section of this chapter, which discusses the point source recommendations by subregional area.

The first categorical recommendation is based upon the continued use of conventional or alternative methods of onsite wastewater disposal. This recommendation is applicable to urban enclaves located in areas with soil conditions and lot sizes which are considered suitable for conventional onsite wastewater disposal methods located anywhere outside the recommended year 2000 sewer service area, or in areas with moderate soil limitations located a significant distance—generally greater than two miles—from a proposed year 2000 sewer service area. The recommendation assumes adequate lot sizes for the required wastewater disposal system.

The second categorical recommendation provides for further analysis at the regional, county, or township level to determine the best waste management practice for the enclave of urban development in question. The local planning program for a portion of these urban areas should consider both alternative onsite wastewater treatment methods as well as connection to the public sanitary sewer system. The areas of urban development covered under this recommendation are generally covered with soils considered to be unsuitable for conventional onsite wastewater treatment, have lot sizes that are unsuitable for such treatment, and are located at distances from existing or proposed public sanitary sewer systems that do not preclude connection of the urban development to that sewer system. For urban areas located significant distances from the nearest public sanitary sewer system and with soil conditions unsuited for conventional onsite wastewater disposal systems, the local planning program should consider only alternative onsite wastewater disposal systems.

## FORMULATION OF ALTERNATIVE PLANS

As noted earlier, major emphasis in the regional sanitary sewerage system planning program was placed upon the formulation of alternative plans centered on the provision of advanced waste treatment where necessary to achieve established water use objectives, with the alternatives differing primarily with respect to the degree of centralization of treatment within urban subareas of the Region. The following discussion describes the process by which alternative plans were formulated, including the designation of subregional areas for system analysis, the determination of plan year 2000 sanitary sewer service areas, the screening of potential alternative plans, the determination of the type and level of treatment required, and the consideration given to private sewage treatment facilities.

### Description of Subregional Areas

The principal facilities used to control point sources of pollution are sanitary sewers. Sanitary sewerage system planning must be done on a regional basis. Land use patterns, which determine the amount and spatial distribution of the hydraulic and pollution loadings to be accommodated by the sanitary sewerage system, develop over an entire urban region in response to basic social and economic forces and to the operation of the urban land market, without regard to artificial corporate limit lines or natural watershed boundaries. The sanitary sewerage facilities, in turn, determine to a considerable extent the potential uses of land areas. These facilities often cross not only corporate limits but watershed boundaries. Thus, sanitary sewerage facility planning cannot be accomplished successfully within the context of a single municipality or county if the municipality or county is part of a larger urban complex. Nor can such planning be accomplished successfully solely within natural watershed areas.

Sanitary sewerage facilities, however, need not form a single integrated system over an entire urbanizing region. Sanitary sewerage facilities may form subsystems related to existing urban concentrations. Although sanitary sewerage facilities may cross watershed boundaries, the location of the major watershed divides must be recognized as an important influence on the development of areawide sanitary sewerage systems. This is true because sanitary sewerage facilities should be developed, to the maximum extent possible, as gravity drainage systems, because treated wastes are often discharged to surface streams, and because legal considerations may prohibit or constrain the transfer of water and sewage across major watershed boundaries. Existing urban concentrations with well-developed sewerage systems must also be recognized as an important influence on the development of areawide sanitary sewerage systems. Such recognition is necessary if maximum use is to be made of the capacity of these systems and the public capital invested in them, and if proper recognition is to be given to the placement of new land use development within or near such concentrations and systems.

The urbanizing region must then form the basic geographic unit for the analysis of sanitary sewerage systems to assure coordination of related subsystems. But the planning effort must recognize the existence of subregional planning areas related both to existing urban concentrations and to natural watershed boundaries. The need to coordinate sanitary sewerage system development in an urbanizing region to effect economies in providing such facilities, to guide land use development, and to protect the natural resource base may dictate the need to adjust and change the delineation of such subregional areas for a more efficient overall system.

The Commission, as part of its regional sanitary sewerage system planning program, delineated geographic subareas of the Region which comprised rational sewerage system planning areas. The boundaries of these 11 areas were delineated on the basis of major natural watershed divides, the exterior boundaries of the Region, the existing and potential service areas of existing centralized sanitary sewerage systems, and the existing and probable future areas of urban development. Because of their use for sewage system planning, these areas provided the best available basis for organizing the sanitary sewerage system inventory required for the areawide water quality management planning effort. The 11 subregional areas are shown on Map 34 and include:

1. The Milwaukee Metropolitan subregional area consists of all of Milwaukee County and those portions of Ozaukee, Racine, Washington, and Waukesha Counties which either presently contract, or are proposed to contract, with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment services.

2. The Upper Milwaukee River subregional area consists of all of the Milwaukee River watershed within the Region north of the northern limits of the City of Mequon.

3. The Sauk Creek subregional area consists of all of the Sauk Creek watershed, that portion of the Sheboygan River watershed lying within the Region, and minor tributary areas which drain directly to Lake Michigan lying generally north of the City of Port Washington.

4. The Kenosha-Racine subregional area consists of all of that area of Kenosha and Racine Counties lying east of IH 94 except that portion within the Des Plaines River watershed.

5. The Root River Canal subregional area consists of all of that part of the Root River watershed in Racine County west of IH 94 which generally drains northerly toward Milwaukee County and the main stem of the Root River at the Milwaukee-Racine County line.

6. The Des Plaines River subregional area consists of all of the Des Plaines River watershed within the Region.

7. The Upper Fox River subregional area consists of nearly all of the Fox River watershed north of the Vernon Marsh in Waukesha County.

8. The Lower Fox River subregional area consists of all of the Fox River watershed within the Region south of the Vernon Marsh, except the urban concentrations at the west end of Lake Geneva in Walworth County.

9. The Upper Rock River subregional area consists of all of that area of the Rock River watershed within the Region lying within Walworth County.

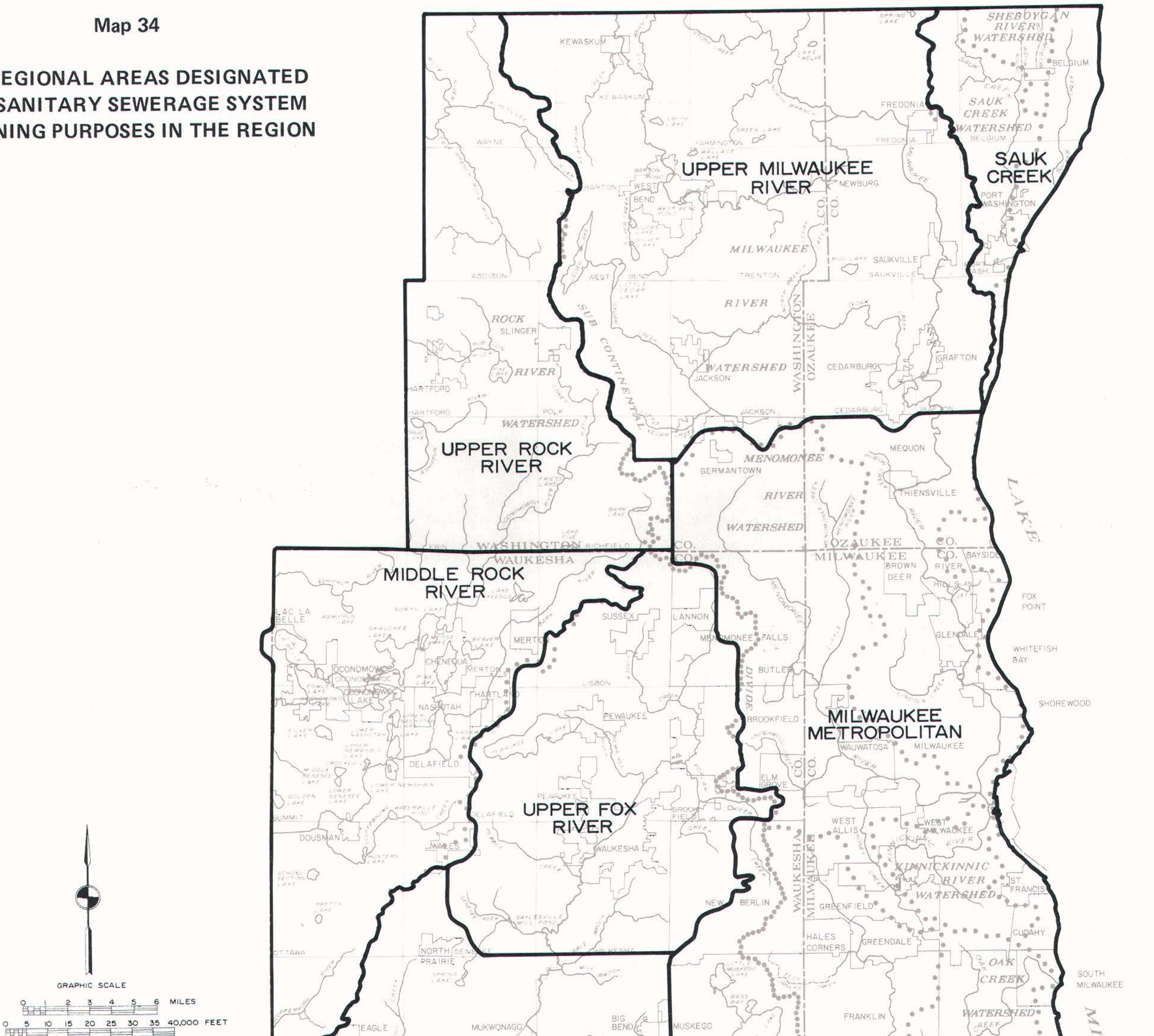
10. The Middle Rock River subregional area consists of all of that area of the Rock River watershed within the Region lying within Waukesha County.

11. The Lower Rock River subregional area consists of all of that area of the Rock River watershed within the Region lying within Walworth County and the urban concentrations in the Fox River watershed at the western end of Lake Geneva.

The boundaries of these 11 subregional areas generally follow major natural watershed divides. Such natural watershed divides were crossed only where necessary to provide a more rational planning area or a more convenient method of presenting the alternative plans considered in the development of the regional sanitary sewerage system plan. In general, it was possible to consider all of the plan alternatives in that effort within

## Map 34

## SUBREGIONAL AREAS DESIGNATED FOR SANITARY SEWERAGE SYSTEM PLANNING PURPOSES IN THE REGION




Eleven distinct subregional areas were identified for sanitary sewerage system planning purposes within the Region. The boundaries of these 11 areas were delineated on the basis of natural major watershed divides, existing and potential service areas of existing centralized sanitary sewerage systems, and existing and probable future areas of urban concentration as recommended in the adopted regional land use plan. In determining the boundaries of the subregional areas, natural watershed divides were crossed only where necessary to recognize the effects of potential urban development and attendant sewerage facilities which crossed such divides.

*Source: SEWRPC.*

the various subregional areas, although in a few instances it became necessary to consider—at least in the preliminary analysis—additional alternatives which transcended even the subregional area boundaries.

### Determination of Plan Year 2000 Sanitary Sewer Service Areas

The adopted regional land use plan and the regional sanitary sewerage system plan provided the basis for the delineation of land areas to which sanitary sewer service should be extended by the plan design year of 2000. In addition, an analysis was undertaken to identify those areas committed to urban development which lie beyond the urban area limits as recommended on the regional land use plan map. Any areas so identified, when contiguous, or in close proximity, to areas recommended for development in the regional land use plan, were added to the proposed year 2000 sewer service areas.

Several distinct year 2000 sewer service areas were thus identified within each subregional sewerage system planning area. The number of areas so identified was based upon several factors, including existing minor civil division boundaries and known communities of interest, particularly with respect to urban development along lakeshores. Once the year 2000 sewer service areas within each subregional area were identified, the process of formulating alternative plans could begin. It is important to note that under any of the alternative plans considered for a given subregional area, the total area proposed to be served remained the same.

The recommended sewer service standards set forth in Chapter II of this volume were utilized in the delineation of areas recommended to be served with centralized sanitary sewer service by the year 2000. Therefore, the recommended sewer service areas include most of the urban concentrations—high-, medium-, and low-density—recommended in the adopted regional land use plan. There exist throughout the Region, however, additional urban areas identified in the plan which were not included within the recommended plan year 2000 sewer service areas. In most cases, these areas are very small and consist of clusters of residential and commercial land uses located along the shorelines of small inland lakes, along the Lake Michigan shoreline, or at rural highway intersections. In some cases, however, these areas lie within incorporated municipalities. These areas were generally not recommended to be provided with sanitary sewer service by the year 2000 because they are very small and isolated from other urban development; consist in part of seasonal homes; are located in or adjacent to the Kettle Moraine State Forest or other environmental corridor areas where additional urban development should not be encouraged; or are located on soils generally well suited for the use of onsite soil absorption sewage disposal systems. Such areas were included in the proposed service area, however, if there was substantial evidence of widespread septic tank system failure, or if the Wisconsin Department of Natural Resources had ordered the installation of sanitary sewers for public health reasons. With respect to those urban areas not included within the recommended year 2000 sewer service area, it is recommended that, should public health authorities, after careful investigation, advise at some future date that centralized sewer service is needed, analyses then be made of the alternatives that are available for the provision of such service. Because of remoteness, it is anticipated that in most cases such service could be economically provided only through construction of a modified onsite disposal system, or through construction of a new, small wastewater treatment facility.

### Alternative Analyses

A systematic procedure was utilized in the regional sanitary sewerage system plan to formulate and evaluate alternative public sanitary sewerage system plans. This process first evaluated the potential for interconnection of community sanitary sewerage systems. A preliminary economic analysis was made for those interconnections found to be potentially feasible, with a more detailed analysis conducted for those systems which continued to appear feasible following the preliminary analysis. Under the areawide water quality management planning program, all interconnections determined to be potentially feasible in the regional sanitary sewerage system plan were reconsidered except in certain cases where the recommendations of the regional sanitary sewerage system plan were previously verified by subsequent local level planning. In other cases, interconnection was recommended to be reconsidered by local facilities planning programs presently being conducted.

For economic analysis purposes, decisions had to be made in constructing the alternative plan elements concerning the abandonment of existing sewage treatment facilities approaching the end of their economic lives. Thus, existing sewage treatment facilities were assumed to be abandoned and replaced by other facilities if one or more of the following factors was found to exist:

1. The existing sewage treatment facility was more than seven years old in 1975, and thus would be more than 15 years old by 1983—the earliest year in which plan implementation involving major facility improvement was assumed for alternative analysis purposes;

2. The capacity of the existing sewage treatment facility was less than one-third that needed to accommodate year 2000 demand.

The foregoing assumptions were made in order to facilitate consistent economic analyses for system planning purposes. In practice, the decision to abandon or reconstruct all or parts of an existing sewage treatment plant will have to be made on the basis of detailed engineering investigations during local level facility planning efforts.

### Consideration of Private Wastewater Treatment Plants

The inventory of known existing point sources of water pollution in the Region conducted as part of the areawide water quality management planning program revealed the existence of 344 known point sources of wastewater other than municipal sewage treatment plants and sanitary and combined sewer flow relief devices (see Volume One, Chapter V of this report). Sixty-seven of these known point sources were categorized as private sewage treatment plants. Major industrial, commercial chemical, or biological treatment facilities which discharge treated effluent directly or indirectly via storm sewer systems to surface water were considered to be private sewage treatment plants. In addition, facilities providing treatment of wastewater followed by effluent disposal in seepage lagoons or by other effluent land application techniques were classified as private sewage treatment plants. Excluded from this classification were certain highly specialized industrial waste treatment facilities which provided minor levels of treatment, such as sedimentation for grit removal and skimming or flotation for oil and grease removal, and which discharged an effluent which was essentially adequately treated by such limited special-purpose treatment steps and, as such, should not be discharged to a sanitary sewerage system. Also not included were septic tanks with conventional soil absorption seepage fields, or clear cooling water discharges having no pretreatment.

In the preparation of the alternative plans, existing private sewage treatment facilities were recommended to be abandoned if the land uses served lay within the proposed year 2000 sewer service area and if the facility was not of a type especially designed to treat unusual industrial wastes. Conversely, if the facility was a special-purpose facility accommodating unusual wastes, it was recommended to be retained. Those facilities serving isolated land uses beyond the proposed year 2000 sewer service area were recommended to be retained provided that satisfactory operation is achieved and maintained. Since those private sewage treatment facilities recommended to be retained in the plan generally are unique in terms of the type of wastes to be treated, recommendations concerning the type and level of treatment to be provided must be formulated on a case-by-case basis during plan implementation.

### Recommended Wastewater Treatment Plan Performance Standards

The design and evaluation of alternative point source pollution abatement plans required assumptions to be made concerning the performance of various types of wastewater treatment facilities. These performance standards were derived from the technical data presented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume One, Point Sources, and relate to pollutant concentrations in treatment plant effluent expressed in terms of monthly averages.

The water quality simulation work conducted under the areawide water quality management planning program and the recommendations concerning wastewater treatment plant effluent concentrations of pollutants have generally been developed utilizing a single set of recommended effluent quality characteristics associated with each recommended level of treatment, as opposed to a broad spectrum of effluent quality characteristics. The level of treatment recommended was selected in conjunction with the degree of pollutant control from nonpoint sources in order to achieve the water quality standards associated with the water use objectives established for each stream. In certain instances, the recommended effluent characteristics developed under the areawide plan have been based in part on site-specific information contained in local facility planning studies and, as such, vary from the specific concentration associated with each level of treatment. The effluent recommendations developed under the areawide water quality management planning program can, in many cases, be expected to be refined by more site-specific studies. These studies could reflect site-specific localized conditions as well as seasonal variations. The six basic specific levels of wastewater treatment and the wastewater treatment plant effluent characteristics associated with each level of treatment utilized in plan development are indicated in Table 90.

Under the regional sanitary sewerage system plan, it was concluded that an ordinary activated sludge secondary wastewater treatment plant incorporating the recirculation of sludge digestion tank supernatant cannot generally be expected to consistently produce, on a monthly average basis, an effluent with less than 15 mg/l of five-day biochemical oxygen demand ($BOD_5$). Such plants can, however, be expected to consistently produce an effluent with less than 15 mg/l of $BOD_5$ on an annual average basis. This conclusion was verified by the state-of-the-art studies except for plants receiving wastes with relatively low influent $BOD_5$ concentrations—about 130 mg/l and below—where it was concluded that a monthly effluent concentration of 15 mg/l was possible utilizing primary sedimentation followed by an activated sludge secondary system and effluent chlorination. Thus, under the second through fifth levels of treatment noted in Table 90, a tertiary treatment unit process is included when the plant influent concentration of $BOD_5$ is relatively high. In some cases, the need for a tertiary unit is avoided when advanced waste treatment facilities for phosphorus and ammonia-nitrogen removal are recommended, since these added treatment steps tend to somewhat reduce the effluent $BOD_5$ concentrations.

The analyses of point source abatement alternatives generally assumed an initial wastewater treatment plant effluent concentration of 15 mg/l of $BOD_5$ to determine if the stream water quality standards could be achieved with that quality of effluent. If a higher level of treatment for $BOD_5$ reduction was required to meet water use objectives, the level of treatment needed was determined on the basis of simulation model results. Higher levels of treatment were then evaluated assuming the performance standards summarized in Table 90 and as documented in SEWRPC Technical Report No. 18, State of the Art of Water Pollution Control in Southeastern Wisconsin, Volume One, Point Sources. Generally, effluent concentrations of lower than 15 mg/l of $BOD_5$ were not evaluated since either the influent characteristics of the treatment plants involved were low enough or the advanced waste treatment component requirements provided for achievement of that $BOD_5$ concentration without the addition of tertiary treatment units.

Table 90

BASIC LEVELS OF WASTEWATER TREATMENT AND ASSOCIATED PLANT EFFLUENT QUALITY

| Effluent Characteristic Level | Effluent Quality (monthly average limits) | | | | |
|---|---|---|---|---|---|
| | Five-Day Biochemical Oxygen Demand (mg/l) | Total Suspended Solids (mg/l) | Total Phosphorus (mg/l) | Ammonia-Nitrogen (mg/l) | Dissolved Oxygen (mg/l) |
| 1 | 30 | 30 | -- | -- | -- |
| 2 | 15 | 15 | -- | -- | -- |
| 3 | 15 | 15 | 1.0[a] | -- | -- |
| 4 | 15 | 20 | 1.0[a] | 1.5[b] | 6.0 |
| 5 | 5 | 5 | 1.0[a] | 1.5[b] | 6.0 |
| 6 | 30 | 30 | Effluent land application in lieu of in-plant advanced waste treatment | | |

[a] *In many instances, a level of 0.1 mg/l of total phosphorus was incorporated into these levels of treatment in order to meet water quality standards.*

[b] *During winter months, an ammonia-nitrogen effluent limit of 3.0 mg/l is specified.*

*Source: SEWRPC.*

## MILWAUKEE METROPOLITAN SUBREGIONAL AREA

The Milwaukee metropolitan subregional area consists of all of Milwaukee County and those portions of Ozaukee, Racine, Washington, and Waukesha Counties which contract, or are proposed to contract, with the Milwaukee-Metropolitan Sewerage Commissions for sewage treatment services. The Milwaukee metropolitan subregional area is comprised of all or portions of several major watersheds, including all of the Menomonee, Kinnickinnic, and Oak Creek watersheds; major portions of the Milwaukee and Root River watersheds; a minor portion of the Fox River watershed in the Muskego Lakes area; and minor areas which drain directly to Lake Michigan. The area contains by far the largest single concentration of urban development within the Southeastern Wisconsin Region and, indeed, comprises the urban-industrial heart of the Region.

Centralized sanitary sewer service in the Milwaukee metropolitan subregional area was provided by nine systems in 1975: the large Milwaukee metropolitan sewerage system and smaller systems operated within the Cities of Franklin and South Milwaukee in Milwaukee County; the Cities of Muskego and New Berlin and the Village of Menomonee Falls in Waukesha County; the Village of Germantown in Washington County; the Village of Thiensville in Ozaukee County; and the Caddy Vista Sanitary District in the Town of Caledonia, Racine County. All but the South Milwaukee system are considered locally to be temporary, with ultimate connection to the Milwaukee metropolitan sewerage system. Together, these nine systems served a total area of about 230.8 square miles and an estimated population of about 1,093,200 persons. Specific population, service area, and related characteristics of the nine systems are presented in Volume One, Chapter V of this report and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

In 1975 there were nearly 44,600 persons living within the Milwaukee metropolitan subregional area not served by centralized sanitary sewers. This population was concentrated within the Milwaukee Metropolitan Sewerage District—primarily within the Cities of Franklin, Greenfield, and Oak Creek and within the existing and proposed contract service areas in the Cities of Brookfield, Mequon, Muskego, and New Berlin and the Villages of Menomonee Falls and Germantown.

### Sewer Service Analysis Areas

The boundaries of the Milwaukee metropolitan subregional area reflect not only the existing, large centralized sanitary sewer system operated by the Milwaukee-Metropolitan Sewerage Commissions but the committed future sewer service area designated by the Commissions in their long-range planning efforts. Studies conducted by the Commission for the Root, Milwaukee, and Menomonee River watersheds have proposed that several small additional areas eventually receive sewer service by the joint Commissions. This total area may be divided into 12 sewer service analysis areas (see Table 91). These 12 areas are also shown on Map 35 and may be described as follows:

## Table 91

### SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE MILWAUKEE METROPOLITAN SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Population Served | Design Hydraulic Loading (mgd) |
| A | Milwaukee Metropolitan Sewerage District . . . . . . | 181.99[b] | 980,900 | 196.00 | 6,900 | 990,800 | 198.11[c] | 221.71 | 1,025,700 | 205.44[c] |
| B | South Milwaukee . . . . . . . | 4.86 | 23,400 | 2.67 | -- | 23,000 | 2.67 | 4.86 | 22,600 | 2.67 |
| C | Mequon . . . . . . . . . . . . | 9.22 | 9,500 | 1.20 | 3,300 | 23,200 | 4.10[d] | 21.82 | 36,200 | 6.83[d] |
| D | Thiensville . . . . . . . . . . . | 1.16 | 4,200 | 0.57 | -- | 4,400 | 0.61 | 1.16 | 4,600 | 0.65 |
| E | Germantown. . . . . . . . . . | 1.88 | 4,600 | 0.80 | 800 | 13,800 | 2.73 | 7.83 | 26,100 | 5.32 |
| F | Menomonee Falls . . . . . . . | 6.17 | 20,400 | 2.26 | 9,200 | 39,800 | 6.33 | 16.22 | 56,100 | 9.76 |
| G | Butler. . . . . . . . . . . . . . | 0.78 | 2,100 | 0.72 | -- | 2,200 | 0.74 | 0.78 | 2,200 | 0.74 |
| H | Brookfield-East . . . . . . . . | 10.86 | 16,300 | 1.90 | 1,600 | 19,400 | 2.55[e] | 11.91 | 21,600 | 3.01[e] |
| I | Elm Grove . . . . . . . . . . . | 3.25 | 7,000 | 1.10 | -- | 6,900 | 1.08 | 3.29 | 7,000 | 1.10 |
| J | New Berlin. . . . . . . . . . . | 5.57 | 13,600 | 1.52 | 12,100 | 36,100 | 6.26[f] | 17.53 | 51,000 | 9.38[f] |
| K | Muskego . . . . . . . . . . . . | 4.75 | 10,200 | 0.92 | 1,200 | 14,300 | 1.79[g] | 10.37 | 19,000 | 2.79[g] |
| L | Caddy Vista . . . . . . . . . . | 0.29 | 1,000 | 0.09 | -- | 1,200 | 0.13 | 0.46 | 1,400 | 0.17 |
| | Total | 230.78 | 1,093,200 | 209.75 | 35,100 | 1,175,100 | 227.10 | 317.94 | 1,273,500 | 247.86 |

[a] *See Map 35.*

[b] *Includes 0.09 square mile in the Village of Bayside, Ozaukee County.*

[c] *Includes contributions from the Wisconsin Electric Power Company—Oak Creek Plant, the Highway 100 Drive-In Theater, and the Union Oil Truck Stop.*

[d] *Includes contributions from the Chalet on the Lake Restaurant, the Federal Foods Company, and the School Sisters of Notre Dame.*

[e] *Includes a contribution from Brookfield Central High School.*

[f] *Includes contributions from the Cleveland Heights Elementary School, the Highway 24 Outdoor Theatre, and the New Berlin Memorial Hospital.*

[g] *Includes a contribution from the Muskego Rendering Company.*

*Source: SEWRPC.*

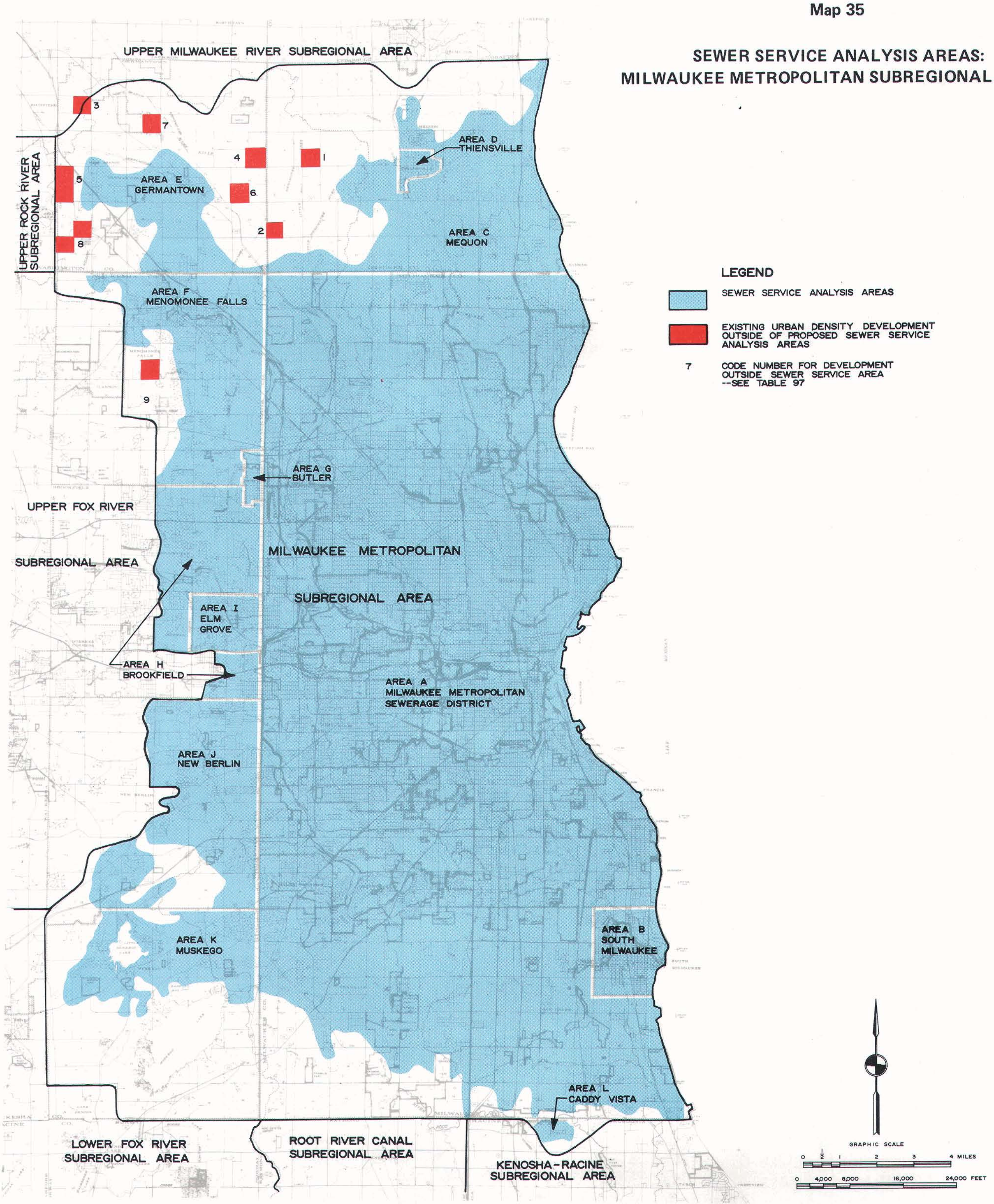
1. Area A—This area consists of the entire Milwaukee Metropolitan Sewerage District and includes all that area of Milwaukee County except the City of South Milwaukee, which has not elected to become part of the District. In 1975 sewer service was provided in this area to about 182 square miles having a total resident population of about 980,900 persons. The total area anticipated to be served by the year 2000 approximates 221.7 square miles with a projected resident population of about 1,025,700 persons. This represents a decrease from the 1.4 million persons forecast for this area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Milwaukee metropolitan" sewer service area in the ensuing discussion.

2. Area B—This area consists of the City of South Milwaukee. In 1975 sewer service was provided in this area to about 4.9 square miles having a total resident population of about 23,400 persons. The entire area may be considered as served by centralized sanitary sewer service. By the year 2000 the area is anticipated to contain a resident population of about 22,600 persons. This represents a decrease from the 27,000 persons forecast for this area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "South Milwaukee" sewer service area in the ensuing discussion.

3. Area C—This area consists of that portion of the City of Mequon recommended for sewer service by the year 2000. In 1975 sewer service was provided in this area to about 9.2 square miles having a total resident population of about 9,500 persons. The total area anticipated to be served by the year 2000 approximates 21.8 square miles with a projected resident population of about 36,200 persons. This represents a significant decrease from the 49,000 persons forecast for this area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Mequon" sewer service area in the ensuing discussion.

Map 35

## SEWER SERVICE ANALYSIS AREAS: MILWAUKEE METROPOLITAN SUBREGIONAL AREA




For analysis purposes, the Milwaukee metropolitan subregional area was divided into 12 sewer service analysis areas. Two of the 12 analysis areas are located in Milwaukee County, one consisting of the entire Milwaukee Metropolitan Sewerage District and the other consisting of the City of South Milwaukee. The remaining 10 areas consist of existing or proposed contract sewer service areas in Ozaukee, Washington, Waukesha, and Racine Counties. The Milwaukee metropolitan subregional area contains by far the largest single concentration of urban development within the Region. This subregional area is comprised of all or portions of several major watersheds, including all of the Menomonee, Kinnickinnic, and Oak Creek watersheds; major portions of the Milwaukee and Root River watersheds; a minor portion of the Fox River watershed in the Muskego Lakes area; and areas which drain directly to Lake Michigan. By the year 2000 it is anticipated that about 1,273,500 persons will reside in these 12 sewer service areas, which will approximate 318 square miles. In 1975 there were about 1,137,800 persons residing in the Milwaukee metropolitan subregional area, of which 1,093,200 were served by centralized sewer service and 44,600 by onsite sewage disposal systems.

*Source: SEWRPC.*

4. Area D—This area consists of the Village of Thiensville. The adopted Milwaukee River watershed plan recommended that this area be connected to the Milwaukee metropolitan sewerage system with *concomitant* abandonment of the existing Thiensville sewage treatment facility. In 1975 sewer service was provided in this area to about 1.2 square miles having a total resident population of about 4,200 persons. The entire area may be considered to be served by centralized sanitary sewer service. The total resident population anticipated to be served by the year 2000 is about 4,600 persons. This represents an increase from the 4,100 persons forecast for this area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Thiensville" sewer service area in the ensuing discussion.

5. Area E—This area consists of that portion of the Village of Germantown recommended for sewer service by the year 2000. In 1975 sewer service was provided in this area to nearly 1.9 square miles having a total resident population of about 4,600 persons. The total area anticipated to be served by the year 2000 approximates 7.8 square miles with a projected resident population of about 26,100 persons. This represents a slight decrease from the 26,700 persons forecast for the area of 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Germantown" sewer service area in the ensuing discussion.

6. Area F—This area generally consists of that portion of the Village of Menomonee Falls lying east of the subcontinental divide. In 1975 sewer service was provided in this area to about 6.2 square miles having a total resident population of about 20,400 persons. By the year 2000 the total area anticipated to be served approximates 16.2 square miles with a projected resident population of about 56,100 persons. This represents a significant decrease from the 72,000 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Menomonee Falls" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Butler. In 1975 sewer service was provided to the entire Village, having a total area of about 0.8 square mile and a total resident population of about 2,100 persons. By the year 2000 the population served is anticipated to reach 2,200 persons. This represents a significant decrease from the 3,100 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Butler" sewer service area in the ensuing discussion.

8. Area H—This area consists of all of the City of Brookfield lying east of the subcontinental divide, except for certain areas already served by the City of Brookfield through the Fox River watershed sanitary sewerage system, located west of the subcontinental divide. In 1975 sewer service was provided in this area to about 10.9 square miles having a total resident population of about 16,300 persons. The total area anticipated to be served by the year 2000 approximates 11.9 square miles with a total projected resident population of about 21,600 persons. This represents a slight increase from the 21,000 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Brookfield-East" sewer service area in the ensuing discussion.

9. Area I—This area consists of the Village of Elm Grove. In 1975 sewer service was provided to the entire Village, having a total sewer service area of about 3.3 square miles and a total resident population of about 7,000 persons. The total resident population projected to be served by the year 2000 remains at about 7,000 persons. This represents a slight decrease from the 7,900 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Elm Grove" sewer service area in the ensuing discussion.

10. Area J—This area consists of all of the City of New Berlin lying east of the subcontinental divide. In 1975 sewer service was provided in this area to about 5.6 square miles having a total resident population of about 13,600 persons. The total area anticipated to be served by the year 2000 approximates 17.5 square miles with a projected resident population of about 51,000 persons. This represents a significant decrease from the 63,000 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "New Berlin" sewer service area in the ensuing discussion.

11. Area K—This area consists of all of that portion of the City of Muskego recommended for sewer service by the year 2000. In 1975 sewer service was provided in this area to about 4.8 square miles with a total resident population of about 10,200 persons. The total area anticipated to be served by the year 2000 approximates 10.4 square miles with a projected resident population of 19,000 persons. This represents a significant decrease from the 32,000 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Muskego" sewer service area in the ensuing discussion.

12. Area L—This area consists of the Caddy Vista Sanitary District in the Town of Caledonia, which is recommended in the adopted Root River watershed plan to be connected to the Milwaukee metropolitan sewerage system, with concomitant abandonment of the existing Caddy Vista sewage treatment facility. In 1975 sewer service was provided in this area to about 0.3 square mile with a total resident population served of about 1,000 persons. The total area anticipated to be served by the year 2000 approximates 0.5 square mile with a projected resident population of nearly 1,400 persons. This represents a decrease from the 1,900 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Caddy Vista" sewer service area in the ensuing discussion.

Formulation of Alternatives

The Milwaukee-Metropolitan Sewerage Commissions and the local communities within the Milwaukee Metropolitan Sewerage District, as well as the existing and proposed contract areas, have over the years conducted many long-range sewerage planning and engineering studies. The sewerage facilities recommended as a result of these studies had been considered committed for planning purposes in the development of the regional sanitary sewerage system plan. With but one exception, all of the communities located within the Milwaukee metropolitan subregional area have agreed to the construction of essentially a single centralized sanitary sewerage system served by two major treatment facilities—the Jones Island and South Shore plants operated by the Milwaukee-Metropolitan Sewerage Commissions—with ultimate abandonment of all remaining public and private sewage treatment facilities that currently serve urban development in the subregional area. The single exception involves the City of South Milwaukee, which has historically declined to join the Milwaukee Metropolitan Sewerage District.

The Milwaukee Metropolitan Sewerage District is presently in the process of preparing a facility plan for a study area which includes the District and all or portions of 10 municipalities included in the existing and proposed contract service areas of the District. As part of that facility planning effort, it is proposed that detailed alternative analyses be conducted regarding the number and location of treatment facilities as well as the type and level of treatment required in order to meet water use objectives. An analysis of the wastewater conveyance system needs is also being conducted under the local facilities planning program. In view of previous developments, the alternative analyses being conducted under the facility planning program are expected to conclude that the decisions regarding abandonment of the existing wastewater treatment facilities at Menomonee Falls, Caddy Vista, and Hales Corners, with subsequent connection of the areas tributary to these plants to the Milwaukee metropolitan sewer system, are in essence committed. The proposed trunk sewer additions needed to connect the service areas presently tributary to the Hales Corners and Menomonee Falls wastewater treatment plants have been approved by the Department of Natural Resources as of December 1978, and local trunk sewer capacity is available for connection of the Caddy Vista sewer service area. Further facility planning analyses are expected to reevaluate the previous recommendations made concerning other wastewater treatment facilities in the Milwaukee metropolitan area.

Because of the previously committed decisions regarding the abandonment of wastewater treatment facilities for a portion of the Milwaukee metropolitan subregional area, and because detailed alternative analyses are presently being developed through local facility planning efforts, further formulation and analysis of alternative sanitary sewerage system plans were not considered for that subregional area. Further alternative analyses would, in effect, duplicate efforts presently planned under the local facility planning program. Thus, the plan for the sanitary sewerage systems within the Milwaukee metropolitan subregional area—as developed under the regional sanitary sewerage system plan—is incorporated, with certain modifications indicated as desirable by subsequent areawide and local facilities planning efforts, as an integral part of the areawide water quality management plan recommendations. The local facility planning program efforts, meanwhile, are being reviewed and coordinated with the regional plan elements. Should the local facility planning findings vary from the recommendations included herein based upon the regional sanitary sewerage system plan, appropriate modifications will be made to incorporate the variations into the areawide water quality management planning program once those variations have been reviewed and approved by all parties concerned.

In May 1976 a moratorium on new sewer connections was imposed on the Milwaukee metropolitan area by the Wisconsin Department of Natural Resources because the sewer system could not meet newly drafted effluent discharge limits. This issue went to court and was resolved in 1977 by a stipulation which set forth the pollution abatement program which Milwaukee must accomplish to meet Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency standards.

Other legal action involving the State of Illinois may also require additional sewerage systems improvements. In January 1977 an Illinois lawsuit against Milwaukee was in active litigation. The ruling of the case significantly altered the pollution abatement program agreed upon earlier between the Milwaukee Sewerage District and the Wisconsin Department of Natural Resources, and imposed water quality standards considerably more stringent than those required by the state and federal governments.

The ruling also indicated that Milwaukee must completely eliminate all combined sewer overflows and provide advanced waste treatment not only for wastewater generated in the separated sewer areas but for combined sewer overflow as well. The decision in the Illinois case is being appealed. The results of these court actions, as of the date of publication of Volume Three of this report, are set forth in Chapter II of that volume.

The major requirements of the agreement with the Wisconsin Department of Natural Resources and the pending Illinois stipulation are summarized in Table 92.

Table 92

SUMMARY OF MAJOR REQUIREMENTS OF THE WISCONSIN DEPARTMENT OF NATURAL RESOURCES AND STATE OF ILLINOIS STIPULATIONS

| Requirement | DNR Stipulation | Illinois Stipulation |
|---|---|---|
| Solids Management Programs | Complete by July 1, 1982 | No specific requirement |
| Elimination of Bypassing in Separated System | Complete relief sewers by July 1, 1983<br>Complete expansion sewers by July 1, 1982<br>Eliminate dry weather bypassing by July 1, 1982 | Eliminate by July 1, 1986<br><br>Bypass at treatment facilities eliminated by December 31, 1986 |
| Sewer System Rehabilitation | Submit Sewer System Evaluation Survey report by July 1, 1980<br>Complete sewer system rehabilitation by July 1, 1986 | Eliminate all overflows by July 1, 1986 |
| Combined Sewer Overflow (CSO) Abatement | Complete design by July 1, 1981<br>Complete CSO abatement facilities and meet water quality standards by July 1, 1993 | Three-stage CSO abatement:<br>700 acre-feet by December 31, 1985<br>1,240 acre-feet by December 31, 1987<br>2,605 acre-feet by December 31, 1989<br>Treat overflows by screening and chlorination |
| Waste Treatment Requirements | Secondary treatment and phosphorus removal by July 1, 1982<br><br>Monthly average<br>30 mg/l BOD<br>30 mg/l suspended solids<br>1.0 mg/l phosphorus<br>400/100 ml membrane filter fecal coliform counts<br><br>Weekly average<br>45 mg/l BOD<br>45 mg/l suspended solids | Advanced wastewater treatment and phosphorus removal consisting of coagulation, sedimentation, and filtration by December 31, 1986<br><br>30 consecutive day average<br>5.0 mg/l BOD<br>5.0 mg/l suspended solids<br><br>Monthly average<br>1.0 mg/l phosphorus<br><br>Not to exceed on any day<br>10 mg/l BOD<br>10 mg/l suspended solids<br><br>Not to exceed on any grab sample, 40/100 membrane filter fecal coliform counts<br><br>Free chlorine residual at all times |

*Source: Milwaukee Metropolitan Sewerage District and SEWRPC.*

Water quality simulation results are presented, with discussion, under the previous section on nonpoint source control elements for the Fox, Kinnickinnic, Menomonee, Milwaukee, and Root River and Oak Creek watersheds.

Sanitary sewerage plans for the 12 sewer service areas that lie within the Milwaukee metropolitan subregional area are described in the following sections.

Proposed Plan—Milwaukee Metropolitan Sewerage District, Mequon, Thiensville, Germantown, Menomonee Falls, Butler, Brookfield, Elm Grove, New Berlin, Muskego, and Caddy Vista Subareas

As noted above, many decisions have been made regarding the development of the Milwaukee metropolitan sewerage system, while other decisions are being evaluated in a local facility plan which is being coordinated with the regional planning work. In view of these developments, the proposed plan included herein is based principally upon the recommendations of the regional sanitary sewerage system plan, which were, in turn, consistent with the long-range sewerage system development plan of the joint Commissions designed to provide for sewerage conveyance and treatment for the entire sewerage district as well as for existing and proposed contract service areas. The following sections describe the basic areawide components of the sewerage system plan for the Milwaukee metropolitan sewer service area.

Treatment Facilities: The proposed plan for the Milwaukee Metropolitan Sewerage District sewer service area recommended that the Mequon, Thiensville, Germantown, Menomonee Falls, Butler, Brookfield, Elm Grove, New Berlin, Muskego, and Caddy Vista sewer service areas be served by the Milwaukee Metropolitan Sewerage District's Jones Island and South Shore wastewater treatment plants. The facilities which were proposed to be abandoned under the regional sanitary sewerage system plan presently serve the Cities of Muskego and New Berlin; the Villages of Germantown, Menomonee Falls, and Thiensville; the Caddy Vista Sanitary District and Rawson Homes Sewer and Water Trust;[19] and the Milwaukee Metropolitan Sewerage District, Hales Corners plant.

In 1975 the wastewater treatment facilities serving the combined Milwaukee Metropolitan Sewerage District at Jones Island and South Shore had a combined hydraulic design capacity of 320 million gallons per day (mgd), and provided secondary waste treatment followed by advanced waste treatment for phosphorus removal and auxiliary waste treatment disinfection prior to discharge to Lake Michigan. It is anticipated that future growth as well as the connection with the Mequon, Thiensville, Germantown, Menomonee Falls, Butler, Brookfield, Elm Grove, New Berlin, Muskego, and Caddy Vista subareas, will require an average hydraulic design capacity for these combined subareas of about 227 mgd in 1985 and about 248 mgd in the year 2000. This year 2000 flow is significantly lower than the estimated 1990 design flow of 320 mgd anticipated under the regional sanitary sewerage system plan.

The two existing plants have an existing collective capacity of about 320 mgd, significantly more than the 245 mgd capacity that would be required to serve the design population assumed to be residing in the service areas of these plants by the year 2000. Theoretically, then, there would be an excessive capacity at the two Milwaukee plants of about 75 mgd. In view of the potential capacity needs, however, for treatment of sewage flows presently bypassed in the Milwaukee system via existing combined sewer overflows and separate sanitary sewer system flow relief devices, it would not appear to be practical to recommend a capacity reduction at the two Milwaukee plants. The local sewerage facilities planning effort now underway by the Milwaukee Metropolitan Sewerage District should consider in more detail the needed treatment plant capacity to serve the District, particularly as that needed capacity relates to flows presently bypassed without treatment. A hydraulic design capacity equal to the existing capacities—200 mgd for the Jones Island plant and 120 mgd for the South Shore facility—has been utilized in the development of the regional plan recommendations.

The proposed plan for the Milwaukee Metropolitan Sewerage District, Mequon, Thiensville, Germantown, Menomonee Falls, Butler, Brookfield, Elm Grove, New Berlin, Muskego, and Caddy Vista subareas includes the provision of secondary waste treatment followed by advance waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection at the Jones Island and South Shore wastewater treatment facilities. These recommendations with respect to level of treatment are the same as those contained in the regional sanitary sewerage system plan.

It is expected that the major local sewerage facilities planning effort now underway for the entire Milwaukee metropolitan subregional area, including the City of South Milwaukee, will reopen the basic system level decisions concerning sewage treatment plants and related trunk sewers in the Milwaukee urbanized area. That local facility plan will also address the treatment requirements associated with infiltration and inflow problems within the sanitary sewerage system, and will include an analysis of alternatives for elimination of pollutant discharges from the combined sewer overflow system. The resultant local sewerage facilities plan is intended, then, upon its adoption by all of the agencies concerned to constitute an amendment to the Section 208 regional water quality management plan herein presented.

The recommended treatment levels and performance standards for the Jones Island and South Shore treatment plants are set forth in Table 93, and the proposed plan for the Milwaukee metropolitan subregional area is shown on Map 36.

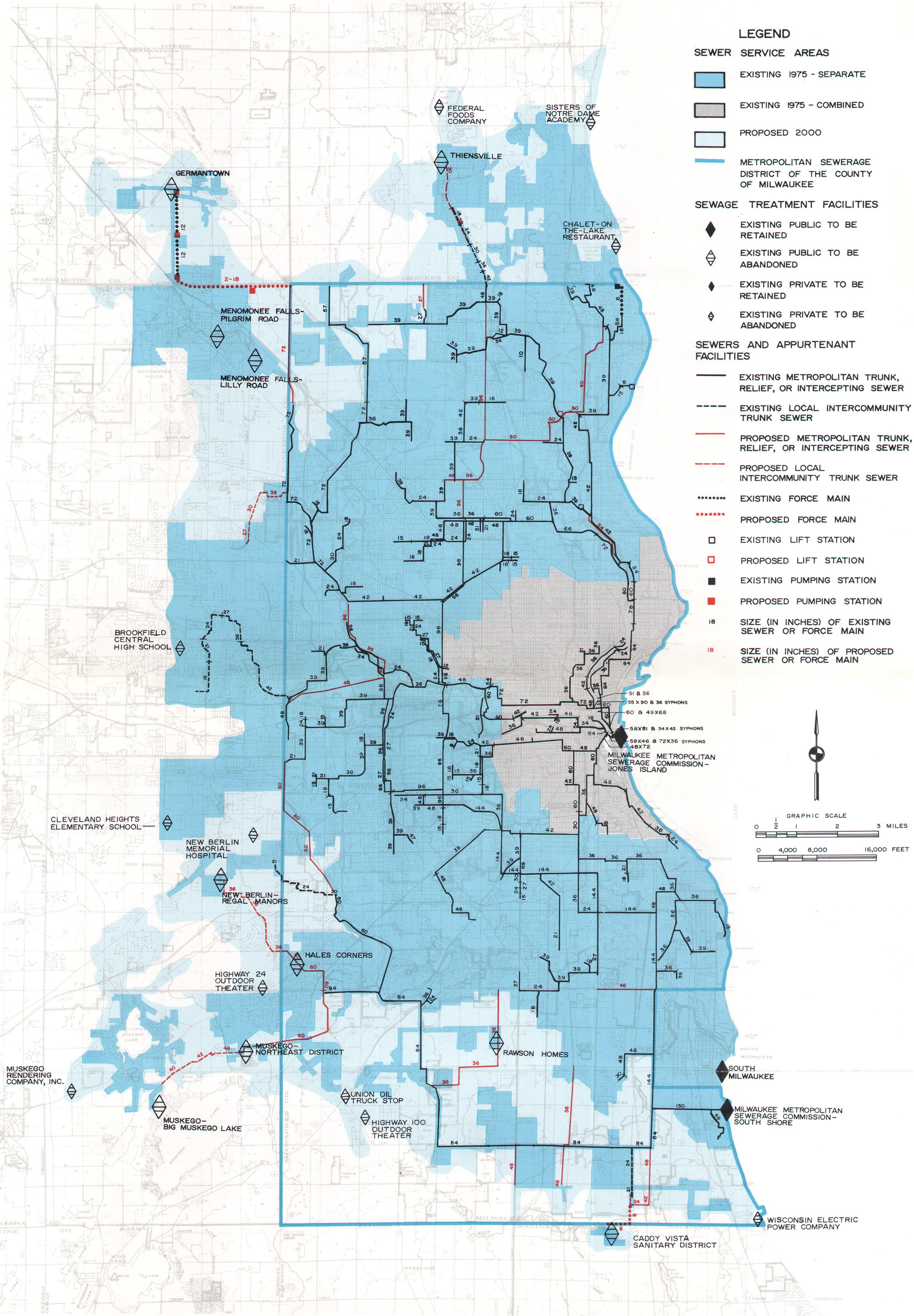
The total present worth over a 50-year analysis period of construction and operation of the recommended treatment facilities for the Milwaukee Metropolitan Sewerage District, Mequon, Thiensville, Germantown, Menomonee Falls, Butler, Brookfield, Elm Grove, New Berlin, Muskego, and Caddy Vista subareas is about $349.4 million. The estimated capital cost for constructing the necessary additional treatment facility is $51.4 million, with an estimated average annual operation and maintenance cost of $19.7 million (see Table 94).

Costs associated with the combined sewer overflow pollution abatement program are included in a later portion of this section. As noted above, the requirements of a stipulation dated May 25, 1977 resulting from the suit brought by the State of Illinois could increase the treatment requirements of the Jones Island and South

[19] *The Rawson Homes Sewer and Water Trust treatment facility was abandoned in 1977.*

**Map 36**

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MILWAUKEE METROPOLITAN SUBREGIONAL AREA: 2000**




The proposed plan for the Milwaukee metropolitan subregional area envisions that three public wastewater treatment facilities serve the area in the year 2000. These three facilities are the Jones Island and South Shore plants operated by the Milwaukee Metropolitan Sewerage District and the South Milwaukee plant operated by the City of South Milwaukee. All three plants are recommended to continue to provide the current level of treatment—secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. The plan also provides for the construction of major trunk sewers necessary to permit the abandonment of 10 existing public wastewater treatment facilities. This plan is generally based upon the trunk sewer and wastewater treatment plant recommendations developed in the regional sanitary sewerage system plan, and upon the long-range plans of the Milwaukee-Metropolitan Sewerage Commissions as modified to reflect updated cost analysis and population and land use data. It is recommended that the facilities planning program presently being conducted by the Milwaukee Metropolitan Sewerage District, upon its adoption by all of the agencies concerned, constitute an amendment to the Section 208 regional water quality management plan.

*Source: Milwaukee Metropolitan Sewerage District and SEWRPC.*

## Table 93

## WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MILWAUKEE METROPOLITAN SEWERAGE DISTRICT SEWER SERVICE AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits)[b] |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Milwaukee Metropolitan Sewerage District Jones Island Plant | 200.0 | 200.0 | Milwaukee Metropolitan Sewerage District Mequon, Thiensville | 1,152,100 | 1,250,100 | Secondary Advanced Auxiliary | Activated Sludge Phosphorus Removal Disinfection | $BOD_5$ Discharge: 20 mg/l Phosphorus Discharge: 1.0 mg/l Fecal Coliform Concentration: 200/100 ml |
| South Shore Plant | 120.0 | 120.0 | Germantown, Menomonee Falls, Butler, Brookfield, Elm Grove, New Berlin, Muskego, Caddy Vista | | | Secondary Advanced Auxiliary | Activated Sludge Phosphorus Removal Disinfection | $BOD_5$ Discharge: 20 mg/l Phosphorus Discharge: 1.0 mg/l Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 36.*

[b] *These recommendations do not reflect the results of a pending Milwaukee Metropolitan Sewerage District stipulation between the State of Illinois, dated May 25, 1977, which may require more stringent wastewater treatment requirements (see Table 92).*

*Source: SEWRPC.*

## Table 94

## DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MILWAUKEE METROPOLITAN SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth (1975-2025) | | | Equivalent Annual (1975-2025) | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plants | | | | | | | | |
| Milwaukee Metropolitan Sewerage District | | | | | | | | |
| Jones Island Plant. . . . . . . | $ 45,000,000[a] | $11,000,000 | $ 34,029,000 | $173,392,000 | $207,421,000 | $ 2,159,000 | $11,000,000 | $13,159,000 |
| Outfall Sewer . . . . . . . . . | 5,000,000 | -- | 3,781,000 | -- | 3,781,000 | 240,000 | -- | 240,000 |
| Subtotal | $ 50,000,000 | $11,000,000 | $ 37,810,000 | $173,392,000 | $211,202,000 | $ 2,399,000 | $11,000,000 | $13,399,000 |
| South Shore Plant. . . . . . . | $ 1,400,000[a] | $ 8,700,000 | $ 1,060,000 | $137,137,000 | $138,197,000 | $ 67,000 | $ 8,700,000 | $ 8,767,000 |
| Subtotal Treatment Plants | $ 51,400,000 | $19,700,000 | $ 38,870,000 | $310,530,000 | $349,400,000 | $ 2,466,000 | $19,700,000 | $22,166,000 |
| Trunk Sewers | | | | | | | | |
| Milwaukee Metropolitan Sewerage District. . . . . . . . | $106,272,000[a] | $ 20,000 | $ 87,719,000 | $ 174,000 | $ 87,893,000 | $ 5,565,000 | $ 11,000 | $ 5,576,000 |
| Caddy Vista. . . . . . . . . . . . | 510,000 | 7,000 | 386,000 | 81,000 | 467,000 | 24,000 | 5,000 | 29,000 |
| Muskego. . . . . . . . . . . . . . | 2,260,000 | 1,000 | 1,709,000 | 16,000 | 1,725,000 | 108,000 | 1,000 | 109,000 |
| New Berlin . . . . . . . . . . . . | 1,350,000 | 1,000 | 1,021,000 | 15,000 | 1,036,000 | 65,000 | 1,000 | 66,000 |
| Brookfield-Menomonee Falls. . | 580,000 | 1,000 | 439,000 | 8,000 | 447,000 | 28,000 | 1,000 | 29,000 |
| Germantown . . . . . . . . . . . | 4,090,000 | 41,000 | 3,093,000 | 548,000 | 3,641,000 | 196,000 | 35,000 | 231,000 |
| Thiensville-Mequon . . . . . . . | 790,000 | 1,000 | 597,000 | 10,000 | 607,000 | 38,000 | 1,000 | 39,000 |
| Subtotal Trunk Sewers | $115,852,000 | $ 72,000 | $ 94,964,000 | $ 852,000 | $ 95,816,000 | $ 6,024,000 | $ 55,000 | $ 6,079,000 |
| Combined Sewer Overflow[b]. . . . | $384,000,000 | $ 1,102,000 | $211,205,000 | $ 9,500,000 | $220,705,000 | $13,399,000 | $ 603,000 | $14,002,000 |
| Subtotal Combined Sewer Overflow | $384,000,000 | $ 1,102,000 | $211,205,000 | $ 9,500,000 | $220,705,000 | $13,399,000 | $ 603,000 | $14,002,000 |
| Total | $551,252,000 | $20,874,000 | $345,039,000 | $320,882,000 | $665,921,000 | $21,889,000 | $20,358,000 | $42,247,000 |

[a] *Costs obtained from Milwaukee Water Pollution Abatement Program Technical Memorandum 4/1-3, Appendix E, March 22, 1978.*

[b] *Costs obtained from the Milwaukee Water Pollution Abatement Program Office Report, Overview of CSO Project, October 1978.*

*Source: SEWRPC.*

Shore plants. Compliance with the effluent limitations set forth in the settlement are estimated to add significantly to the above-noted wastewater treatment costs for the Milwaukee Metropolitan Sewerage District wastewater treatment plants.

The total present worth over a 50-year analysis period of construction and operation of the additional treatment facilities needed to comply with the State of Illinois pending stipulation with the Milwaukee Metropolitan Sewerage District is about $172 million, exclusive of the costs related to elimination of combined sewer overflow system pollutant discharges. The estimated capital cost for constructing the necessary additional treatment facilities is $104 million, with an estimated average annual operation and maintenance cost of $5.9 million.

Combined Sewer Overflow Abatement Plan

The above-described sewage treatment facilities and trunk sewers are directed both at extending existing sewerage systems throughout the entire Milwaukee metropolitan subregional area and at providing flow relief to separate sanitary sewers now experiencing periods of overloading. An additional problem of major proportions present in the Milwaukee metropolitan subregional area concerns the combined sewer overflows (CSO's). This water quality problem was studied as part of the Milwaukee River watershed study.[20] The findings of that study were incorporated into the regional sanitary sewerage system plan. Those previous regional planning studies recommended construction of a combination deep tunnel storage/flow-through treatment system to collect, convey, and adequately treat all combined sewer overflows caused by up to two inches of runoff throughout the combined sewer service area in Milwaukee County, such recommendation being subject, however, to reconfirmation as part of a combined sewer overflow preliminary engineering study being conducted by the Milwaukee Metropolitan Sewerage District.

Under the current facilities planning program, the Milwaukee Metropolitan Sewerage District is reevaluating alternative combined sewer overflow pollution abatement techniques. The facilities planning program is considering the following four basic concepts as possible solutions to the combined sewer overflow problem:

Sewer Separation—Under this concept, storm runoff and sanitary sewage are separated. Storm runoff would be collected and discharged directly to receiving waters, while sanitary sewage would be collected and conveyed to treatment facilities.

Instream Treatment—Under this concept, discharge of CSO to receiving waters would continue, while various pollution control techniques would be applied to the three rivers within the CSO area. These techniques include dredging, aeration, and/or flow augmentation.

Out-of-Basin—Under this concept, all or part of the CSO would be collected and treated, and effluent discharge would occur outside of the three river basins, i.e., Lake Michigan.

In-Basins—This option is similar to the out-of-basin concept in that all or part of the CSO would be collected and treated; however, effluent discharge would occur within one or more of the river basins.

Within each of these four basic concepts various alternatives were developed and evaluated under the preliminary engineering study. As a result, two basic alternatives remain; namely, 1) full separation—including separation on private property—of the combined sewer areas through the construction of a new system of sanitary sewers and the use of the existing combined sewers for storm sewers; and 2) the construction of a deep tunnel system to collect and store combined sewer overflows with subsequent treatment and disposal. Auxiliary instream measures under consideration to achieve the water use objectives and supporting standards include instream aeration and the dredging of the rivers and inner harbor. These two basic alternatives, as well as combinations of the alternatives, are now undergoing evaluation, including a determination of the effects of each alternative on surface water quality. It is intended that, upon completion and adoption by all parties concerned, the recommendations of the Milwaukee combined sewer overflow study will become an amendment to the areawide water quality management plan. For the purpose of estimating the costs entailed in implementation of the areawide plan, which is being completed in advance of the Milwaukee combined sewer overflow study, it was determined to include the most recent available cost of the alternative last agreed upon by a technical and citizens advisory committee after public deliberation on the economical, social, and environmental effects of the alternatives being considered, that committee action being taken under the regional sanitary sewerage system planning program. This, most recently agreed-upon alternative, is the deep tunnel collection, storage, and treatment alternative. The costs are based upon the data compiled by the Milwaukee Metropolitan Sewerage District and documented in the October 11, 1978 report entitled Overview of CSO Project.

The estimated total present worth over a 50-year analysis period of construction and operation of the sewerage system improvements needed for the combined sewer overflow pollution abatement program is $220.7 million. The estimated capital cost for construction of the needed improvements is $384 million, with an estimated average annual operation and maintenance cost of $1.1 million.

Metropolitan District Trunk Sewers

Within the Milwaukee metropolitan subregional area, the plan recommendations and costs are based, with but one exception, on completion of the long-range trunk sewer plan set forth in the adopted regional sanitary sewerage

[20] *See SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume Two, Alternative Plans and Recommended Plan, October 1971.*

system plan and the Milwaukee Metropolitan Sewerage District trunk, relief, and intercepting sewer plan. These sewer extensions are designed to provide sanitary sewer service to existing and proposed urban development within the District and its contract service areas, and to provide relief to portions of the trunk sewer system now experiencing surcharging. The single exception is the Ryan Creek trunk sewer, a sewer designed to serve the southernmost portions of the Cities of Franklin and Muskego. Based upon the regional land use plan, this sewer would not be needed to accommodate urban development by the year 2000. The presently adopted long-range plan of the Milwaukee-Metropolitan Sewerage Commissions—with the exception of the Ryan Creek sewer—is shown on Map 36.

Refinements to this long-range plan, including the possible staging beyond the plan design year, are expected to be developed under the facilities planning program presently being conducted by the Milwaukee Metropolitan Sewerage District. The facility planning program will evaluate the effect on the long-range plan of the future populations allocated to the various sewer service areas under the adopted regional land use plan. Modifications to the long-range plan for the Milwaukee Metropolitan Sewerage District being developed under that facilities planning program are being coordinated with and will be incorporated into the areawide water quality management planning program following adoption by the agencies concerned. Many of the extensions involve key sewers designed to provide relief to portions of the trunk sewer system now experiencing periods of overloading. The total present worth over a 50-year analysis period of construction and operation of these trunk sewers is about $87.9 million. The capital cost for constructing these trunk sewers is about $106 million, with an average annual operation and maintenance cost of about $20,000.

The Milwaukee metropolitan trunk sewer system is being designed in part to provide for selective routing of sewage flows to the two major treatment facilities. Map 37 shows those portions of the District and contract area directly tributary to the Jones Island treatment facility, those portions directly tributary to the South Shore treatment facility, and those portions which may be selectively routed to either facility as needs dictate.

Local Trunk Sewers: A number of major trunk sewers will be needed in the District and in the existing and proposed contract sewer service areas to provide for abandonment of existing temporary wastewater treatment facilities as well as for the future extension of sewer service to areas not now served. A total of six such major sewers are shown on Map 36.

These sewers represent the presently adopted long-range plans for the Milwaukee metropolitan subregional area as documented in the regional sanitary sewerage system plan and in the facilities plan for pollution abatement facilities in the Metropolitan Sewerage District completed in November 1976 by the Metropolitan Sewerage District. The sizing and timing of construction of these sewers will be reevaluated during the current local facility planning program being conducted by the Milwaukee Metropolitan Sewerage District. Modifications being developed under that facilities planning program are being coordinated with and are intended to be incorporated into the areawide water quality management planning program following adoption by the agencies concerned. These six sewers may be described as follows:

1. A trunk sewer designed to permit abandonment of the existing wastewater treatment facility serving the Caddy Vista Sanitary District. This abandonment, which was initially recommended in the adopted Root River watershed plan, is proposed to be accommodated through a local trunk sewer constructed by the City of Oak Creek with sufficient capacity to provide for Caddy Vista sewage conveyance, pending completion of local studies on the feasibility of construction of a Milwaukee metropolitan trunk sewer in the area to which this trunk sewer is ultimately planned to be connected. The total present worth over a 50-year analysis period of construction and operation of this trunk sewer is about $467,000. The capital cost for construction of this trunk sewer is about $510,000, with an average annual operation and maintenance cost of about $7,000.

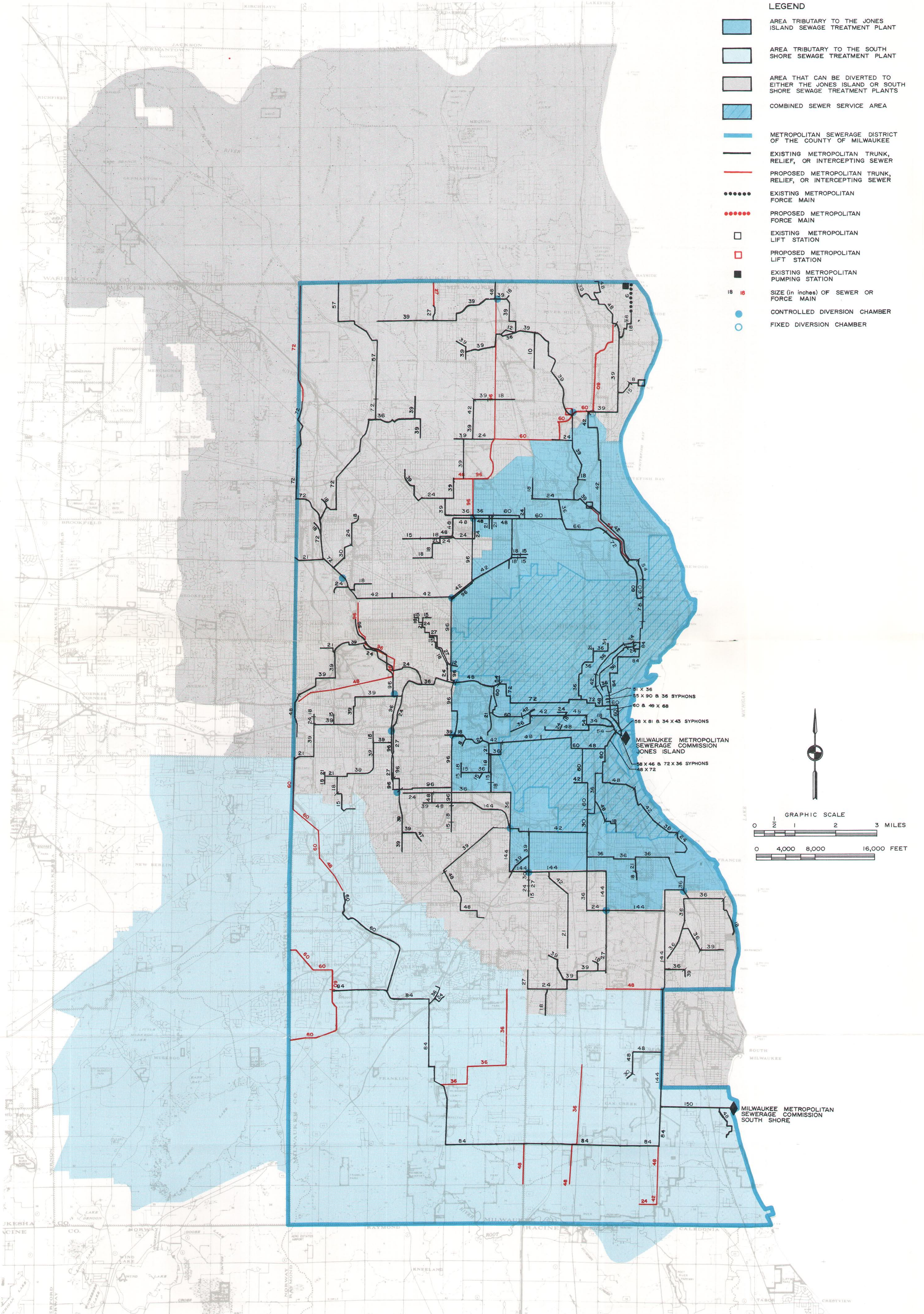
2. A trunk sewer designed to permit abandonment of two wastewater treatment plants currently operated by the City of Muskego on a temporary basis. This major trunk sewer would extend from a proposed metropolitan trunk sewer at the Milwaukee-Waukesha County line about one-half mile south of W. Rawson Avenue extended. The total present worth over a 50-year analysis period of construction and operation of this trunk sewer is about $1,725,000. The capital cost for this trunk sewer is about $2,260,000, with an average annual operation and maintenance cost of about $1,000.

3. A trunk sewer designed to permit abandonment of the existing Regal Manors wastewater treatment facility currently operated by the City of New Berlin on a temporary basis. This sewer would connect to a proposed metropolitan trunk sewer at the Milwaukee-Waukesha County line near W. Grange Avenue. The total present worth over a 50-year analysis period of construction and operation of this trunk sewer is about $1,036,000. The capital cost for construction of this trunk sewer is about $1,350,000, with an average annual operation and maintenance cost of about $1,000.

4. A trunk sewer designed to serve portions of the City of Brookfield and Village of Menomonee Falls and to be constructed by a joint sewerage commission formed for that purpose. While this trunk sewer would not permit the abandonment of any existing wastewater treatment facilities, it has been included in the plan since it is areawide

## Map 37

### AREAS TRIBUTARY TO THE JONES ISLAND AND SOUTH SHORE WASTEWATER TREATMENT PLANTS OPERATED BY THE MILWAUKEE-METROPOLITAN SEWERAGE COMMISSIONS




The proposed Milwaukee Metropolitan trunk sewer system is designed, in part, to provide for selective routing of sewage flows to the two major treatment facilities. As noted on the above map, portions of the system are directly tributary to the Jones Island treatment facility, portions are directly tributary to the South Shore facility, and a major portion, including the Thiensville, Mequon, Germantown, Brookfield, and Elm Grove sewer service areas and a major portion of the Milwaukee Metropolitan Sewage District sewer service area, can be diverted to either the Jones Island or South Shore plant.

*Source: Milwaukee Metropolitan Sewerage District and SEWRPC.*

in nature, serving more than a single contract area community. The total present worth over a 50-year analysis period of construction and operation of this trunk sewer is about $447,000. The capital cost for construction of this trunk sewer is about $580,000, with an average annual operation and maintenance cost of about $1,000.

5. A trunk sewer designed to permit abandonment of the wastewater treatment facility serving the Village of Germantown. The proposed trunk sewer would consist of a series of pumping stations and force mains and would connect with a proposed metropolitan trunk sewer at the extreme northwesterly corner of Milwaukee County. This trunk sewer connection, which initially was proposed as a solution to an areawide sewerage system problem studied as part of the Commission's federal grant review function, will effectively serve the entire Village of Germantown through the year 2000. Ultimately, it may be desirable to provide a gravity flow connection for Germantown through the Village of Menomonee Falls. The total present worth over a 50-year analysis period of construction and operation of this trunk sewer is about $3,641,000. The capital cost for construction of this trunk sewer is about $4,090,000, with an average annual operation and maintenance cost of about $41,000.

6. A trunk sewer proposed to permit the abandonment of the wastewater treatment facility serving the Village of Thiensville as initially recommended in the Milwaukee River watershed plan. This trunk sewer will also serve a portion of the City of Mequon. The total present worth over a 50-year analysis period of construction and operation of this trunk sewer is about $607,000. The capital cost for construction of this trunk sewer is about $790,000, with an average annual operation and maintenance cost of about $1,000.

In total, the present worth over a 50-year analysis period of construction and operation of all six of these trunk sewers is about $7,923,000. The capital cost for construction of all six of these trunk sewers is about $9,580,000, with an average annual operation and maintenance cost of $52,000. These cost estimates are set forth in Table 94.

Proposed Plan—South Milwaukee Subarea

In 1975 the wastewater treatment facility serving the City of South Milwaukee had an average hydraulic design capacity of 6.0 mgd, and provided secondary waste treatment followed by advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to Lake Michigan. Additions to the existing facility were completed in 1972, bringing the plant average hydraulic design capacity up to about 6.0 mgd.

It is anticipated that the loadings to South Milwaukee sewer service area will remain stable at about 2.67 mgd in 1985 and 2000. These loadings are less than the hydraulic design capacity of the existing facility, and thus no expansion is proposed at the treatment facility. This year 2000 design flow is significantly lower than estimated 1990 design flow of the 6.0 mgd anticipated under the regional sanitary sewerage system plan. This change is the result of the slightly different method of calculating the design hydraulic loading used in the later study which considered the existing (1975) loading as the principal factor for a facility, with no or relatively limited projected increased tributary population.

The proposed plan for the South Milwaukee subregional area includes the provision of secondary waste treatment followed by advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection at the existing South Milwaukee wastewater treatment plant.

The results of a settlement of a lawsuit brought by the State of Illinois may affect future treatment requirements for the South Milwaukee wastewater treatment plant. Officials of the City of South Milwaukee signed a January 11, 1977 settlement to a Lake Michigan pollution lawsuit brought by the State of Illinois which would commit the City to providing higher levels of waste treatment at its wastewater treatment facility. The agreement, which is binding on South Milwaukee only if all necessary federal and state funds are made available, requires effluent limitations of 10 milligrams per liter (mg/l) of five-day biochemical oxygen demand ($BOD_5$), 10 mg/l of suspended solids, and 1.0 mg/l of phosphorus.

In 1977 the City initiated a facilities planning project to evaluate wastewater treatment and conveyance needs. A major component of the facilities planning program is the infiltration inflow studies.

The recommended treatment levels and performance standards for the South Milwaukee wastewater treatment plant are set forth in Table 95. The proposal is shown on Map 38.

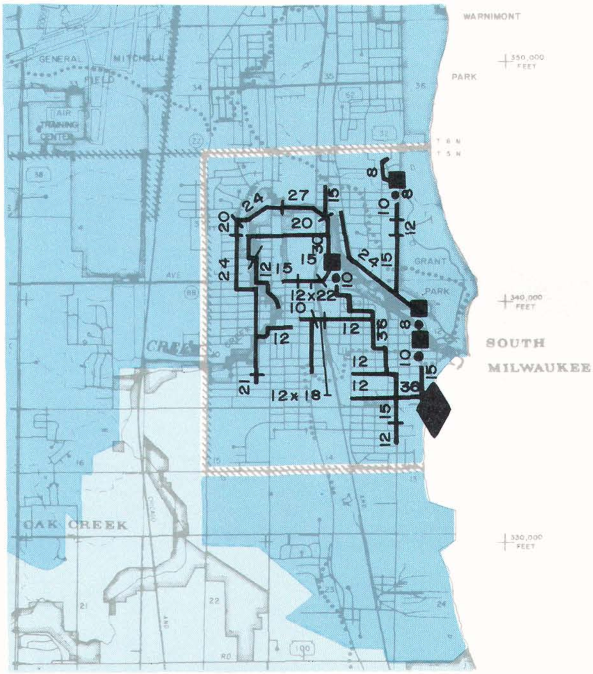
The total present worth over a 50-year analysis period of construction and operation of the recommended treatment and conveyance facility for the South Milwaukee sewer service area is about $6,351,000. The estimated capital cost for constructing the outfall sewer is $450,000. The estimated average annual operation and maintenance cost of the treatment and conveyance facilities is $360,000 (see Table 96).

As noted above, the requirements of a settlement of a suit brought by the State of Illinois could increase the treatment requirements at the South Milwaukee wastewater treatment plant. Compliance with the effluent limitations set forth in the agreement are estimated to add significantly to the above-noted costs for the South Milwaukee wastewater treatment plant.

The total present worth over a 50-year analysis period of construction and operation of the added facilities needed to comply with the State of Illinois agreement is about $911,000. The estimated capital cost for constructing

## Map 38

### PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SOUTH MILWAUKEE SEWER SERVICE AREA: 2000




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

EXISTING FORCE MAIN

EXISTING PUMPING STATION

GRAPHIC SCALE

It is proposed that the existing City of South Milwaukee wastewater treatment facility continue to serve the City while providing secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. Economic analyses performed under the regional sewerage system study as documented in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin: 1990, found that, on an equivalent annual cost basis, it would be more economical to abandon the South Milwaukee facility than to expand and continue to operate the facility and make necessary improvements to provide secondary and advanced waste treatment. During the course of conducting that study, however, the City of South Milwaukee did request and receive approval from the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency to increase the average hydraulic design capacity of the plant and to provide for secondary and advanced levels of waste treatment. Since these improvements were made in 1972, it was concluded that retention of the South Milwaukee facility was and would remain a committed decision through the design year 2000.

*Source: SEWRPC.*

the associated treatment facility additions is $700,000, with an estimated average annual operation and maintenance cost of $40,000.

Abandonment of Public Wastewater Treatment Facilities

Implementation of the foregoing plan recommendations would permit the abandonment of 10 public wastewater treatment facilities in the Milwaukee metropolitan subregional area. These facilities are those currently serving the Village of Thiensville, the Village of Germantown, the Village of Menomonee Falls (Pilgrim Road plant and Lilly Road plant), the City of New Berlin (Regal Manors plant), the City of Muskego (Big Muskego plant and Northeast District plant), the Village of Hales Corners, and the Caddy Vista Sanitary District in the Town of Caledonia. The facility serving the Rawson Homes Sewer and Water Trust in Franklin was abandoned in 1977.

Private Wastewater Treatment Plants

There are 11 known privately owned wastewater treatment facilities in the Milwaukee metropolitan subregional area which in general serve single isolated land use enclaves and treat wastes which can be considered for inclusion in public sanitary sewerage systems. These facilities currently discharge relatively minor amounts of wastes to the streams and groundwater in the Milwaukee metropolitan subregional area. These 11 facilities serve: Brookfield Central High School in the City of Brookfield; Cleveland Heights Elementary School, Highway 24 Drive-in Theatre, and New Berlin Memorial Hospital in the City of New Berlin; Muskego Rendering Company, Inc., in the City of Muskego; Chalet on the Lake Restaurant, Federal Foods Company, and School Sisters of Notre Dame in the City of Mequon; Wisconsin Electric Power Company-Oak Creek Plant in the City of Oak Creek; and Highway 100 Drive-in Theatre and Union Oil Truck Stop in the City of Franklin. All 11 of these plants lie within the year 2000 proposed service area, and hence would be abandoned upon implementation of the proposed sewerage system plan for the Milwaukee metropolitan, Brookfield, New Berlin, Muskego, Franklin, Oak Creek, and Mequon subareas. The facilities operated by the Federal Food Company and the Highway 24 Outdoor Theatre have been essentially abandoned prior to 1978, and wastes are presently (1979) conveyed to a holding tank for storage prior to being collected by a private tank truck operator.

Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are nine enclaves of unsewered urban development located outside the proposed year 2000 sewer service area as shown on Map 35. The estimated population of these enclaves in 1975 and the year 2000 and the distance from each enclave to the nearest proposed year 2000 sewer service area are listed in Table 97. In a general analysis described earlier in this chapter, the cost of providing public sewerage service to enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that analysis, it was concluded that wastewater disposal for these nine enclaves of unsewered urban development should be considered further in one of two ways.

## Table 95

### WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SOUTH MILWAUKEE SEWER SERVICE AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits)[b] |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| City of South Milwaukee | 2.67 | 2.67 | South Milwaukee | 23,000 | 22,600 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 36.*

[b] *These recommendations do not reflect the results of a pending stipulation between the Milwaukee Metropolitan Sewerage District and the State of Illinois, dated May 25, 1977, which may require more stringent wastewater treatment requirements.*

*Source: SEWRPC.*

## Table 96

### DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SOUTH MILWAUKEE SEWER SERVICE AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth (1975-2025) | | | Equivalent Annual (1975-2025) | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant<br>City of South Milwaukee | | | | | | | | |
| Facilities . . . . . . . . . | $ -- | $360,000 | $652,000 | $5,417,000 | $6,069,000 | $41,000 | $344,000 | $385,000 |
| Outfall Sewer . . . . . . | 450,000 | -- | 282,000 | -- | 282,000 | 18,000 | -- | 18,000 |
| Subtotal | $450,000 | $360,000 | $934,000 | $5,417,000 | $6,351,000 | $59,000 | $344,000 | $403,000 |
| Trunk Sewers—None | $ -- | $ -- | $ -- | $ -- | $ -- | $ -- | $ -- | $ -- |
| Total | $450,000 | $360,000 | $934,000 | $5,417,000 | $6,351,000 | $59,000 | $344,000 | $403,000 |

*Source: SEWRPC.*

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment, coupled with a suitable program for monitoring and maintenance of the onsite systems. This plan recommendation is generally applicable to areas with soils and lot sizes which are suitable for use of conventional onsite wastewater treatment systems. All nine urban enclaves are included in this category—the City of Mequon—Section 17 and Section 30 in Ozaukee County, the Village of Germantown—Section 7, Section 13, Section 19, and Section 24, Dhiensville-Rockfield, and Willow Creek, all in Washington County, and the Village of Menomonee Falls—Section 16 in Waukesha County. It is recommended that this proposal be verified by local studies.

For unsewered urban areas, of the second category the plan provides for the conduct of further site-specific planning to determine the best wastewater management practice. None of the unsewered urban areas are included in this category. In general, areas in this category have soil conditions and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

Sanitary Sewer System Flow Relief Devices

In addition to the combined sewer outfalls discussed above, in 1975 there were 379 known sanitary sewer system flow relief devices located in the Milwaukee metropolitan subregional area. The proposed plan recommends that local facilities planning efforts include the formulation of programs leading to the elimination of these sewage flow relief devices. In this light it is noted that the Milwaukee Metropolitan Sewerage District is presently conducting an infiltration/inflow analysis as part of its facilities planning program. The initial results of that analysis indicate that a total maximum day wastewater flow rate of 719 mgd occurs in the separate sanitary sewer system under existing conditions, assuming no infiltration/inflow removal and the elimination of all

Table 97

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE MILWAUKEE METROPOLITAN SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population 1975 | Estimated Resident Population 2000 | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | Ozaukee County | | | |
| 1 | City of Mequon–Section 17 | 145 | 114 | 1.0 |
| 2 | City of Mequon–Section 30 | 180 | 165 | 1.0 |
| | Washington County | | | |
| 3 | Village of Germantown–Section 7 | 136 | 130 | 1.3 |
| 4 | Village of Germantown–Section 13 | 117 | 197 | 1.1 |
| 5 | Village of Germantown–Section 19 | 419 | 410 | 0.1 |
| 6 | Village of Germantown–Section 24 | 150 | 190 | 0.5 |
| 7 | Dhiensville-Rockfield | 107 | 118 | 0.8 |
| 8 | Willow Creek | 302 | 317 | 0.4 |
| | Waukesha County | | | |
| 9 | Village of Menomonee Falls–Section 16 | 227 | 250 | 0.7 |
| Total | | 1,783 | 1,891 | - - |

[a] *See Map 35.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

bypassing. Excessive infiltration/inflow was identified in 337 of 363 study areas established for the project. Further analysis is being conducted to consider treatment and conveyance needs as well as sewer system rehabilitation requirements. This study is being coordinated with the relief sewer and combined sewer overflow pollution abatement phases of the facility planning.

Other Known Point Sources of Wastewater

There are a total of 163 known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Milwaukee metropolitan subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment or following treatment directly to surface waters or to storm sewers tributary to streams and watercourses. The discharge characteristics of these 163 other point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975. It is recommended that these other point sources reduce the effluent constituents of $BOD_5$, ammonia-nitrogen, phosphorus, and fecal coliform to levels generally recommended as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar surface water bodies. It is recommended that these point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Effluent characteristics reported by these point sources which could require treatment are noted in Table 98.

The degree of treatment and costs for constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with pretreatment requirements for existing discharges to public sanitary sewerage systems. However, in order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area, an estimate was made of the treatment requirements which appeared to be needed from the limited data available on these point sources. This cost analysis excludes existing and proposed industrial systems modification to reduce pollutant discharge, existing industrial treatment facilities, and existing pretreatment of waste conveyed to public sanitary sewerage systems. It should be pointed out that industries which are noted as requiring further treatment, based upon 1975 effluent characteristics data, may have been modified through treatment or process changes which have taken place since the data were reported, and in some cases further treatment may no longer be needed. In other cases, industries may be able to modify the plant discharges satisfactorily through process changes as opposed to treatment of the discharge. Additionally, other industries not indicated to need treatment may not have included data on certain parameters which may need treatment consideration. The total present worth over a 50-year analysis period of construction and operation of the treatment facilities associated with correction of existing discharges of industrial wastes is estimated to be about $6,010,000. The capital cost for constructing the facilities is about $4,282,000, with an estimated average annual cost of $211,000 over the design period 1975 to 2000.

## UPPER MILWAUKEE RIVER SUBREGIONAL AREA

The Upper Milwaukee River subregional area consists of all of the Milwaukee River watershed within the Southeastern Wisconsin Region north of the northern limits of the City of Mequon. In recent years, this area has been subject to relatively rapid urban growth, particularly in the Cedarburg, Grafton, Saukville, and West Bend urban areas.

Centralized sanitary sewer service in the Upper Milwaukee River subregional area was provided by eight systems in 1975: those operated by the Cities of Cedarburg and West Bend; and the Villages of Fredonia, Grafton, Kewaskum, Jackson, Newburg, and Saukville. Together, the service areas of these eight systems comprised an area of about 13.4 square miles and served an estimated population of about 48,600 persons. In 1975 there were about 26,900 persons residing within the subregional area who were not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the eight systems are presented in Volume One, Chapter V of this report, and in

Table 98

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION—MILWAUKEE METROPOLITAN SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Allied Smelting Corporation | City of West Allis | 0.121 | 43rd Street ditch via storm sewer | Oil and grease |
| Allis Chalmers Corporation | City of West Allis | 0.070 | Menomonee River via storm sewer | Suspended solids |
| AMF, Inc.—Harley-Davidson Company | City of Wauwatosa | 0.040 | Tributary of Menomonee River | Five-day biochemical oxygen demand, suspended solids |
| Appleton Electric Company, Lighting Products Division | City of South Milwaukee | 0.034 | Oak Creek via storm sewer | Five-day biochemical oxygen demand, oil and grease |
| Aqua-Chem, Inc.—North Plant No. 2 | City of Milwaukee | 0.038 | Lincoln Creek via storm sewer | Suspended solids, phosphorus, ammonia-nitrogen |
| Babcock & Wilcox—Tubular Products Division | Village of West Milwaukee | 0.825 | Menomonee River via storm sewer | Five-day biochemical oxygen demand, suspended solids, oil and grease |
| Badger Meter,Inc. | Village of Brown Deer | 0.007 | Milwaukee River via storm sewer | Heavy metals |
| Briggs & Stratton Corporation | City of Wauwatosa | 0.025 | Menomonee River via storm sewer | Five-day biochemical oxygen demand, oil and grease |
| Bucyrus Erie Company (Oak Creek) | City of South Milwaukee | 0.780 | Oak Creek | Suspended solids, oil and grease |
| Chicago, Milwaukee, St. Paul & Pacific Railroad Company | City of Milwaukee | 0.320 | Menomonee River via drainage ditch | Five-day biochemical oxygen demand, suspended solids, phosphorus, ammonia-nitrogen, oil and grease |
| Chicago & North Western Railway | Village of Butler | 0.001 | Menomonee River via drainage ditch | Suspended solids |
| Chris Hanson's Laboratory, Inc. | City of West Allis | 0.050 | Honey Creek via storm sewer | Five-day biochemical oxygen demand, phosphorus |
| Eaton Corporation | City of West Allis | 0.129 | 43rd Street ditch via storm sewer and Drainage Ditch | Five-day biochemical oxygen demand, phosphorus |
| Falk Corporation—Plant No. 1 | City of Milwaukee | 0.428 | Menomonee River | Suspended solids, phosphorus |
| Florence Eisman, Inc. | City of Milwaukee | 0.001 | Milwaukee River | Five-day biochemical oxygen demand, suspended solids, temperature |
| Grey Iron Foundry, Inc. | City of West Allis | 0.370 | Honey Creek | Suspended solids, oil and grease |
| Heil Company—Bulk Trailer Division | City of Milwaukee | 0.011 | Kinnickinnic River via Storm Sewer | Five-day biochemical oxygen demand, suspended solids, phosphorus |
| Hentzen Chemical Coatings, Inc. | City of Milwaukee | 0.049 | Little Menomonee River via storm sewer | Temperature |
| Joseph Schlitz Brewing Company | City of Milwaukee | 2.275 | Milwaukee River via storm sewer | Fecal coliform |
| Longview Fibre Company—Downing Box Division | City of Milwaukee | 0.005 | Milwaukee River via storm sewer | Temperature |
| Maynard Steel Casting Corporation | City of Milwaukee | 0.110 | Kinnickinnic River | Suspended solids |
| Menomonee Falls Water Utility | Village of Menomonee Falls | 0.163 | Menomonee River | Suspended solids |

Table 98 (continued)

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Milwaukee Solvay Coke Company . . . . . | City of Milwaukee | 4.820 | Kinnickinnic River | Suspended solids |
| Milwaukee Waterworks— Howard Avenue Plant . . . . . . . . . . . | City of Milwaukee | 0.416 | Kinnickinnic River | Suspended solids |
| Milwaukee Waterworks— Linwood Avenue Plant. . . . . . . . . . . | City of Milwaukee | 1.013 | Lake Michigan | Suspended solids |
| Mobil Oil Corporation Lube Plant . . . . . | City of Milwaukee | 0.005 | Menomonee River via storm sewer | Suspended solids |
| Motor Casting Plant No. 1 . . . . . . . . . | City of West Allis | 0.220 | Woods Creek via storm sewer | Suspended solids, ammonia-nitrogen |
| Motor Casting Plant No. 2 . . . . . . . . . | City of Milwaukee | 0.018 | Honey Creek via storm sewer | Five-day biochemical oxygen demand |
| Oak Creek Water Filtration Plant . . . . . | City of Oak Creek | 0.612 | Lake Michigan | Suspended solids |
| Oster Corporation . . . . . . . . . . . . . . | City of Milwaukee | 0.041 | Milwaukee River via storm sewer | Suspended solids |
| Outboard Marine Corporation— Plant No. 1, Research Annex . . . . . . . | City of Milwaukee | 0.262 | Lincoln Creek via storm sewer | Temperature |
| Pelton Casteel, Inc. . . . . . . . . . . . . . | City of Milwaukee | 0.080 | Kinnickinnic River via drainage ditch | Five-day biochemical oxygen demand |
| Peter Cooper Corporation— U. S. Glue and Gelatin Division. . . . . . | City of Oak Creek | 3.205 | Lake Michigan via storm sewer | Suspended solids |
| P.P.G. Industries, Inc. . . . . . . . . . . . . | City of Oak Creek | 0.004 | Root River via drainage ditch | Heavy metals |
| Rexnord, Inc.—Nordberg Machinery Group. . . . . . . . . . . . . . | City of Milwaukee | 0.448 | Kinnickinnic River via storm sewer | Suspended solids, phosphorus |
| Shell Oil Company. . . . . . . . . . . . . . | City of Milwaukee | 0.001 | Lake Michigan | Ammonia-nitrogen |
| Teledyne Wisconsin Motor— Outfall No. 5 . . . . . . . . . . . . . . . . | City of West Allis | 0.009 | 43rd Street ditch via storm sewer | Suspended solids |
| Union Oil of California— General Mitchell Field . . . . . . . . . . . | City of Milwaukee | Intermittent | Wilson Park Creek via storm sewer | Suspended solids |
| W. A. Krueger Company, Inc. . . . . . . . | City of Brookfield | 0.010 | Underwood Creek | Suspended solids |
| Western Electric Power Company, Inc.— Wisconsin Service Center . . . . . . . . . | City of Milwaukee | 0.001 | Milwaukee River via drainage ditch | Heavy metals |
| Wisconsin Electric Power Company— Commerce Street Plant . . . . . . . . . . | City of Milwaukee | 0.200 | Milwaukee River | Temperature |
| Wisconsin Electric Power Company— Oak Creek Plant Outfall No. 7 . . . . . . | City of Oak Creek | 4.080 | Lake Michigan via storm sewer | Suspended solids |
| Wisconsin Electric Power Company— Wells Street Plant. . . . . . . . . . . . . . | City of Milwaukee | 0.024 | Milwaukee River | Suspended solids, temperature |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System, reports provided under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Sewer Service Analysis Areas

A total of nine sewer service analysis areas may be identified within the Upper Milwaukee River subregional area (see Table 99). These nine sewer service analysis areas are shown on Map 39 and may be described as follows:

1. Area A—This area consists of the Village of Kewaskum and environs. In 1975 sewer service was provided in this area to about 0.7 square mile, having a total resident population of about 2,000 persons. The total area anticipated to be served by the year 2000 approximates 1.5 square miles, with a projected resident population of about 4,900 persons. This represents an increase from the 3,200 persons forecast for this area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Kewaskum" sewer service area in the ensuing discussion.

2. Area B—This area consists of the City of West Bend and environs. In 1975 sewer service was provided in this area to about 6.3 square miles, having a total resident population of about 21,000 persons. The total area anticipated to be served by the year 2000 approximates 12.2 square miles with a projected resident population of about 41,600. This represents a substantial increase from the 25,300 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "West Bend" sewer service area in the ensuing discussion.

3. Area C—This area consists of the Village of Jackson and environs. In 1975 sewer service was provided in this area to about 0.4 square mile, having a total resident population of about 2,000 persons. By the year 2000, the sewer service will probably be extended to a total area of about 2.3 square miles, with a projected resident population of about 6,000 persons. This represents a substantial increase from the 1,700 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Jackson" sewer service area in the ensuing discussion.

4. Area D—This area consists of the Village of Newburg and environs. In 1975 sewer service was provided in this area to about 0.2 square mile, having a total resident population of about 600 persons. The total area anticipated to be served by the year 2000 approximates 1.4 square mile, with a projected resident population of about 2,400 persons. This represents a substantial increase from the 1,100 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Newburg" sewer service area in the ensuing discussion.

5. Area E—This area consists of the Village of Fredonia and environs. In 1975 sewer service was provided in this area to about 0.7 square mile, having a total resident population of about 1,500 persons. The total area anticipated to be served by the year 2000 approximates 1.7 square miles, with a projected resident population of about 2,100 persons. This represents an increase from

Table 99

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Population Served | Design Hydraulic Loading (mgd) |
| A | Kewaskum | 0.65 | 2,000 | 0.32 | 500 | 3,700 | 0.68 | 1.48 | 4,900 | 0.93 |
| B | West Bend | 6.28 | 21,000 | 3.70 | 900 | 29,900 | 5.57 | 12.16 | 41,600 | 8.03 |
| C | Jackson | 0.43 | 2,000 | 0.26 | - - | 3,500 | 0.72[b] | 2.27 | 6,000 | 1.24[b] |
| D | Newburg | 0.19 | 600 | 0.07 | 200 | 1,400 | 0.24 | 1.36 | 2,400 | 0.45 |
| E | Fredonia | 0.66 | 1,500 | 0.28 | - - | 1,800 | 0.34 | 1.65 | 2,100 | 0.41 |
| F | Waubeka | - - | - - | - - | 500 | 600 | 0.13 | 0.51 | 600 | 0.13 |
| G | Grafton | 2.15 | 8,800 | 0.88 | 1,000 | 11,900 | 1.53 | 5.66 | 16,800 | 2.56 |
| H | Cedarburg | 2.58 | 10,400 | 1.41 | 1,300 | 14,700 | 2.31 | 6.56 | 18,300 | 3.07 |
| I | Saukville | 0.43 | 2,300 | 0.29 | 300 | 4,400 | 0.73 | 2.25 | 6,500 | 1.17 |
| | Total | 13.37 | 48,600 | 7.21 | 4,700 | 71,900 | 12.25 | 33.90 | 99,200 | 17.99 |

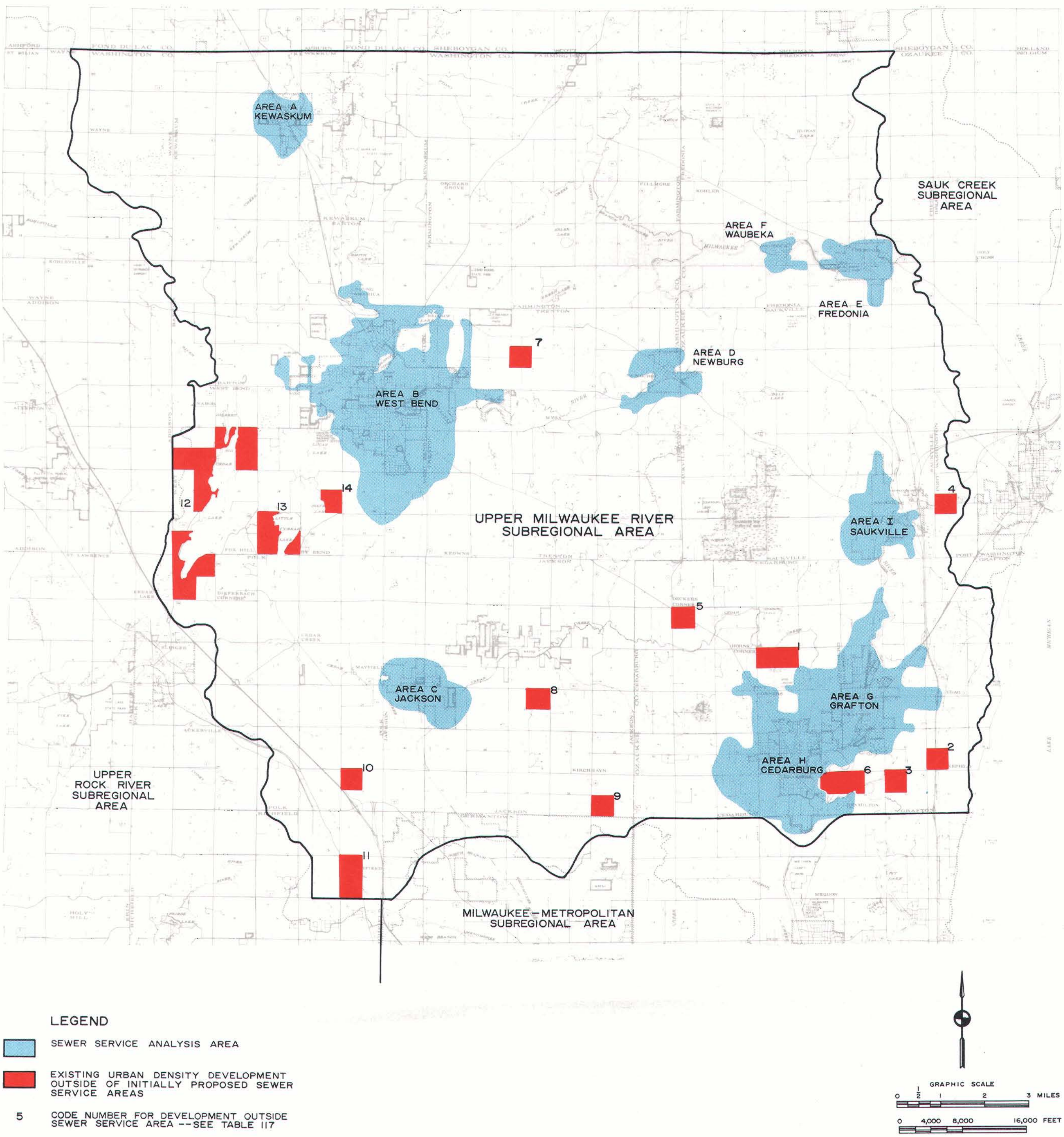
[a] *See Map 39.*

[b] *Includes a contribution from the Libby, McNeill and Libby—Jackson private wastewater treatment facility.*

*Source: SEWRPC.*

Map 39

## SEWER SERVICE ANALYSIS AREAS: UPPER MILWAUKEE RIVER SUBREGIONAL AREA




Nine distinct sewer service analysis areas were identified within the Upper Milwaukee River subregional area. In eight of the areas—the Cities of Cedarburg and West Bend and the Villages of Fredonia, Grafton, Jackson, Kewaskum, Newburg, and Saukville centralized sanitary sewer service was being provided in 1975. The remaining sewer service analysis area consisting of the unincorporated Village of Waubeka is presently unsewered. However, local officials have proposed that public sanitary sewer service be provided in the area. Based upon an analysis of the findings of detailed lake management studies conducted by the Wisconsin Department of Natural Resources, Silver Lake, Big Cedar Lake, and Little Cedar Lake, the urban development around those lakes was not included in the recommended year 2000 sewer service area. By the year 2000 about 99,200 persons are expected to reside in these nine sewer service areas, which will approximate 33.9 square miles. In 1975 there were about 75,500 persons residing in the Upper Milwaukee River subregional area, of which 48,600 were served by centralized sewer service and 26,900 by onsite sewage disposal systems.

*Source: SEWRPC.*

the 1,800 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Fredonia" sewer service area in the ensuring discussion.

6. Area F—This area consists of the unincorporated village of Waubeka. No sewer service was provided in this area in 1975. However, local officials have proposed that sanitary sewer service be provided to this area. The total area anticipated to be served by the year 2000 approximates 0.5 square mile, with a projected resident population of about 600 persons. This subarea was not recommended to be provided with public sanitary sewer service in the regional sanitary sewerage system plan. This area is referenced as the "Waubeka" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Grafton and environs. In 1975 sewer service was provided in this area to about 2.2 square miles, having a total resident population of about 8,800 persons. The total area anticipated to be served by the year 2000 approximates 5.7 square miles, with a projected resident population of about 16,800 persons. This represents an increase from the 10,700 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Grafton" sewer service area in the ensuing discussion.

8. Area H—This area consists of the City of Cedarburg and environs. In 1975 sewer service was provided in this area to about 2.6 square miles, having a total resident population of about 10,400 persons. The total area anticipated to be served by the year 2000 approximates 6.6 square miles, with a projected resident population of about 18,300 persons. This represents an increase from the 14,300 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Cedarburg" sewer service area in the ensuing discussion.

9. Area I—This area consists of the Village of Saukville and environs. In 1975 sewer service was provided in this area to about 0.4 square mile, having a total resident population of about 2,300 persons. The total area anticipated to be served by the year 2000 approximates 2.3 square miles, with a projected resident population of about 6,500 persons. This represents a substantial increase from the 2,600 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Saukville" sewer service area in the ensuing discussion.

Summary of Previously Prepared Regional Plan Elements

The Milwaukee River watershed plan, adopted in March 1972 by the Regional Planning Commission, contained specific recommendations pertaining to sewerage system development and stream water quality management for the Upper Milwaukee River subregional area.[21] These recommendations were developed from a detailed examination of five basic stream water quality management alternative plan elements for the Upper Milwaukee River wateshed.

Following the preparation and adoption of the Milwaukee River watershed plan, several developments occurred which necessitated a reevaluation of the recommendations in the adopted plan prior to their integration into the regional sanitary sewerage system plan.[22] This reevaluation was undertaken in preparation of the regional sanitary sewerage system plan. Because of the extensive consideration of alternative sanitary sewerage system plans under the Milwaukee River watershed study, the procedure for evaluating detailed alternative plans normally utilized in the development of the regional sanitary sewerage system plan was not utilized, and only a recommended plan was presented. This plan consisted of the basic stream water quality management recommendations included in the adopted Milwaukee River watershed plan, modified to reflect the results of the reevaluation under the regional sanitary sewerage system planning program.

Formulation of Alternatives

Several local planning efforts have taken place which represent steps toward the implementation of the Upper Milwaukee River watershed water quality management recommendations of the Milwaukee River watershed plan and the regional sanitary sewerage system plan. Local facility planning has been completed or is nearing completion for the Cedarburg, Fredonia, Grafton, Jackson, and West Bend sewer service areas. With regard to the number and locations of public wastewater treatment facilities in the Upper Milwaukee subregional area, these local planning efforts are expected to verify the recommendations of the regional sanitary sewerage system plan. In view of these developments, it was concluded that the recommendations of the regional sanitary sewerage system plan with regard to the number and locations of public treatment facilities in the Upper Milwaukee River subregional area are generally committed and should be incorporated into the areawide water quality management plan without further alternative consideration, except for certain modifications indicated as desirable by subsequent system and facilities planning efforts. Alternatives were evaluated with regard to the type of treatment to be utilized. Two modifications to the regional sanitary sewerage system plan recommendations are incorporated into the areawide water quality management planning

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[21] *See SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed.*

[22] *For a detailed discussion of the developments affecting the Milwaukee River watershed recommendations and the alternative analyses which were reevaluated, see Chapter XI of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.*

program. One modification is the addition of the Waubeka subarea to the areas recommended for sewer service. Local planning by the area has been initiated and a sanitary district has been formed within the sewer service area. Sewer service has also been recommended for the Waubeka area in the adopted regional land use plan. The Waubeka sewer service area is less than one mile from the Fredonia sewer service area, and interconnections of these two sewer service areas is considered a viable alternative to separate treatment facilities serving each area. Thus, alternative analyses were made regarding both joint and separate treatment of wastewater for the Waubeka and Fredonia sewer service areas.

A second modification to the regional sanitary sewerage system plan recommendations incorporated into the areawide water quality management planning program involves the Tri-lakes sewer service area. One of the issues raised in the public hearings on the 1990 regional sanitary sewerage system plan concerned the recommendation in that plan that centralized sanitary sewer service be provided to existing urban development along the shorelines of Big Cedar Lake, Little Cedar Lake, and Silver Lake, commonly known as the Tri-lakes area, in the Towns of West Bend and Polk. The new West Bend sewage treatment facility has been designed with sufficient capacity to accept sewage flow from such existing urban development. Because of the concern expressed by residents of the Tri-lakes area about the effect of the installation of sanitary sewers on urban development around the lakes, and because of questions raised by such residents concerning the need for sewers to protect lake water quality, the regional sanitary sewerage system plan concluded that the provision of sanitary sewer service to the Tri-lakes area should be reevaluated in a more detailed lake water quality management study.

More detailed lake water quality management studies of the three lakes comprising the Tri-lakes area were accordingly conducted by the Wisconsin Department of Natural Resources in cooperation with the lake communities concerned, and at the same time by the Commission under the areawide water quality management planning effort. These studies concluded that septic tanks contributed less than 20 percent of the annual phosphorus loading to the lakes, and that under the existing and proposed year 2000 development conditions the total nutrient load to these lakes is relatively low. Therefore, the installation of centralized sanitary sewers to serve existing urban development in the Tri-lakes area would not significantly improve water quality. Furthermore, these studies indicated that there was no reason to believe that, given a proper program of septic tank system inspection and maintenance over time and further given curtailed urban development in the lake subwatershed as called for in the adopted regional land use plan, septic tank effluent would constitute a significant source of water pollution in the foreseeable future. Based upon these studies, then, the areawide water quality management plan does not propose that centralized sanitary sewer service be extended to the Tri-lakes area. The capacity provided at the West Bend sewage treatment plant for ultimate service to the Tri-lakes area, which is estimated at about 1.0 million gallons per day (mgd), or 19 percent of the total capacity of the new plant, can thus be made available to accommodate other urban development in the rapidly growing West Bend urban area.

Water quality simulation results are presented under the previous section which discusses the Milwaukee River watershed and the nonpoint source control element recommendations for that watershed. Sanitary sewerage system plans for the sewer service areas that lie within the Upper Milwaukee River subregional area are described in the following sections.

Proposed Plan—Kewaskum Subarea

In 1975 the wastewater treatment facility serving the Kewaskum sewer service area had an average hydraulic design capacity of 1.0 mgd, and provided a secondary level of waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Kewaskum sewer service area of about 0.68 mgd in 1985 and about 0.93 mgd in the year 2000. This year 2000 design flow is the same as that anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the Milwaukee River, it will be necessary for this facility to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection, followed by land application of treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River. The recommendations concerning treatment and discharge to surface waters are, with one exception, the same as those contained in the regional sanitary sewerage system plan. That plan did not recommend the provision of advanced waste treatment for nitrification. The recommendation for nitrification was added based upon an analysis of instream conditions which affect the toxicity of ammonia.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application is considered to be a viable alternative to providing secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent disinfection for treatment plants the size of the Kewaskum facility. The recommendation of the areawide water quality management planning program is based on the treatment and effluent land application alternative, but recognizes the need for more detailed local facilities planning to examine the alternatives providing for a surface water discharge as well as land application. Should local facilities planning efforts indicate that land application of plant effluent is not practical, then an alternative treatment system designed to ultimately achieve the level of treatment noted above as needed to meet water quality standards with effluent discharge to the surface waters should be considered. The recommended treatment levels and performance standards for the Kewaskum wastewater treatment plant are set forth in Table 100, and the proposal is shown on Map 40.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Kewaskum sewer service area is about $4,328,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $2,442,000, with an estimated average annual operation and maintenance cost of $146,000 (see Table 101).

Alternative Plans—West Bend Subarea

In 1975 the wastewater treatment facility serving the West Bend sewer service area had an average hydraulic design capacity of about 2.5 mgd, and provided a secondary level of waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the sewer service area of about 5.57 mgd in 1985 and about 8.03 mgd in the year 2000. This year 2000 flow is significantly higher than the estimated 1990 design flow of 6.10 mgd anticipated under the regional sanitary sewerage system plan.

As previously noted, the City of West Bend had completed facilities planning, and construction was initiated in 1978 on major modifications to upgrade and expand

Table 100

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE KEWASKUM SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) 1985 | 2000 | Sewer Service Analysis Area Served[a] | Estimated Population 1985 | 2000 | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| Village of Kewaskum | 0.68 | 0.93 | Kewaskum | 3,700 | 4,900 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 39.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus), and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River.*

*Source: SEWRPC.*

Table 101

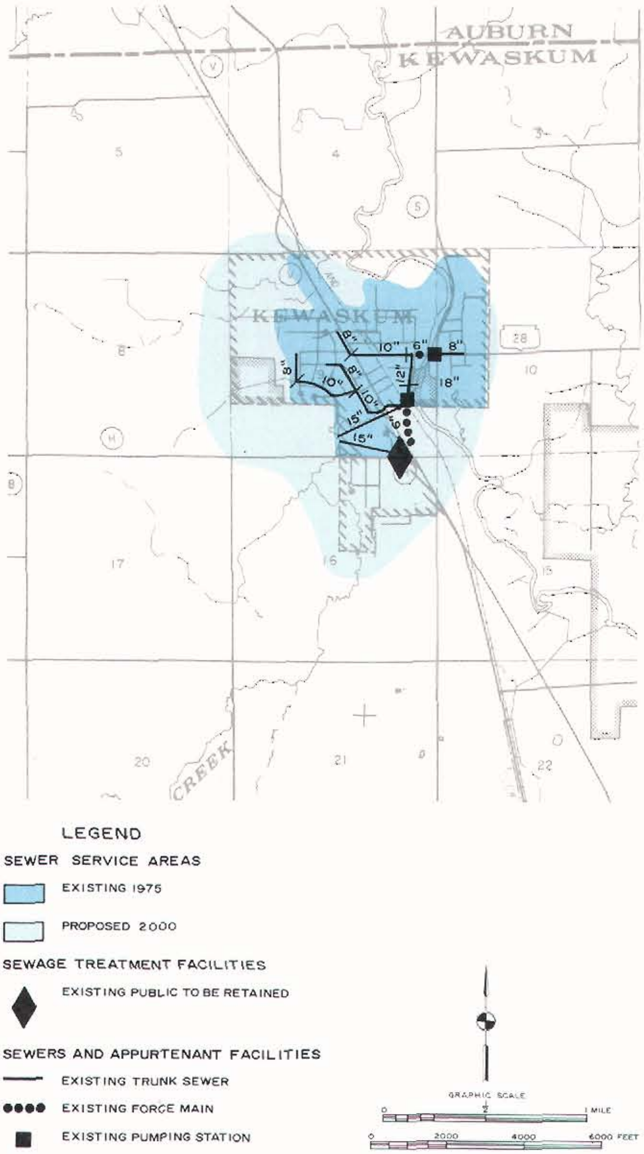
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE KEWASKUM SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant<br>Village of Kewaskum | | | | | | | | |
| Facilities . . . . . . . . | $2,127,000 | $146,000 | $1,879,000 | $2,268,000 | $4,147,000 | $119,000 | $144,000 | $263,000 |
| Land. . . . . . . . . . . | 315,000 | - - | 181,000 | - - | 181,000 | 11,000 | - - | 11,000 |
| Subtotal | $2,492,000 | $146,000 | $2,060,000 | $2,268,000 | $4,328,000 | $130,000 | $144,000 | $274,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $2,442,000 | $146,000 | $2,060,000 | $2,268,000 | $4,328,000 | $130,000 | $144,000 | $274,000 |

*Source: SEWRPC.*

Map 40

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE KEWASKUM SEWER SERVICE AREA—
UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the existing Kewaskum wastewater treatment plant be maintained at its present capacity to serve the year 2000 sewer service area. In order to meet the established water use objectives for the Milwaukee River, it will be necessary for the plant to be upgraded to provide either land application of plant effluent following the current secondary level of treatment, or conventional advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River.

*Source: SEWRPC.*

the city's wastewater treatment plant. The plant has been designed to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River. The plant is proposed to have an average hydraulic design capacity of 9.00 mgd.

In order to meet the established water use objectives for the Milwaukee River, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of the plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection. The recommendations concerning treatment and discharge to surface waters differ from recommendations contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. The regional sanitary sewerage system plan recommended that the plant effluent have a total phosphorus concentration of 1.0 mg/l, while the updated recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analysis described earlier in this chapter, the effluent land application alternative and the treatment and discharge alternative should be considered further in the alternative analyses for a plant the size of the West Bend facility. Accordingly, two treatment alternatives were considered for the West Bend sewer service area. The first alternative would provide for continued discharge of the West Bend wastewater treatment plant effluent to the Milwaukee River following the required levels of waste treatment. The second alternative assumes the provision of a land application system for the disposal of secondary treatment plant effluent from the treatment facility. The recommended treatment levels and performance standards for both of the alternatives are set forth in Table 102, and the two proposals are shown on Map 41.

The first alternative is based upon the provision of secondary waste treatment followed by advanced waste treatment for ammonia-nitrogen and phosphorus removal, utilizing conventional chemical treatment for phosphorus removal, biological nitrification, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to the Milwaukee River. The total present worth over a 50-year analysis period of construction and operation of the treatment facilities included under Alternative Plan 1 for the West Bend sewer service area is about $21,607,000. estimated capital cost for constructing the necessary additional treatment facilities is $9,075,000, with an estimated average annual operation and maintenance cost of $951,000 (see Table 103).

Table 102

## WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WEST BEND SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of West Bend | 5.57 | 8.03 | West Bend | 29,900 | 41,600 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of West Bend | 5.57 | 8.03 | West Bend | 29,900 | 41,600 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application[b] | $BOD_5$ Discharge: 30.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 39.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus), and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River.*

*Source: SEWRPC.*

Table 103

## DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WEST BEND SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

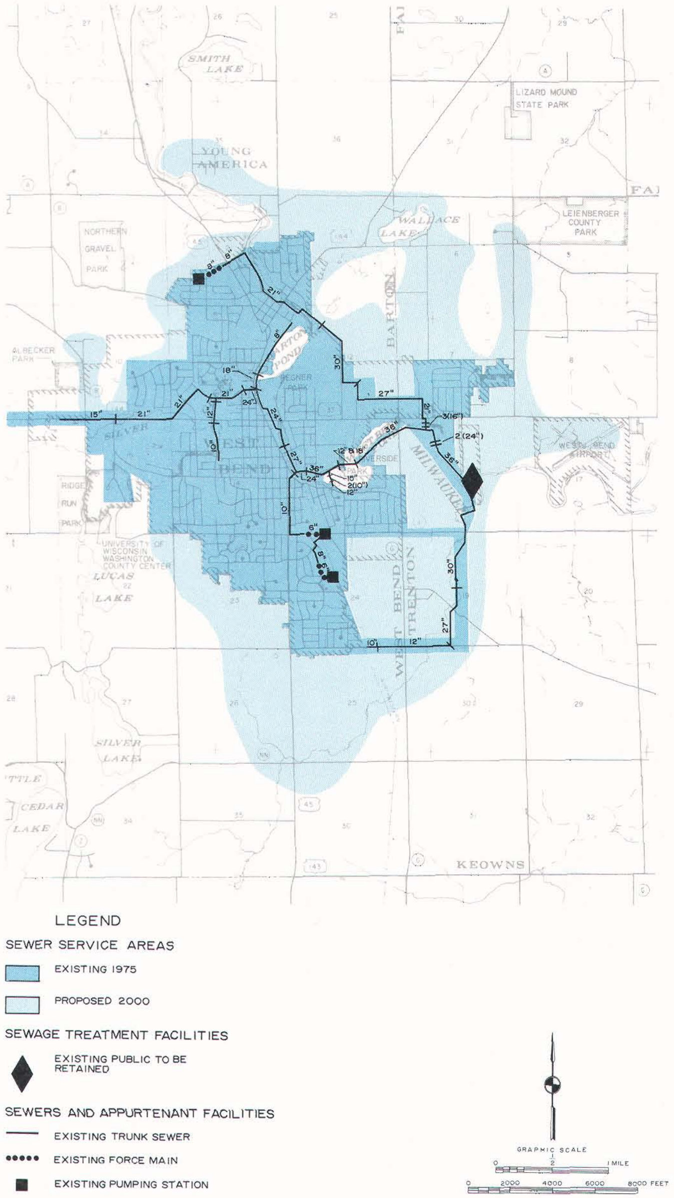
| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant City of West Bend . . . . . | $ 9,075,000 | $951,000 | $ 6,863,000 | $14,744,000 | $21,607,000 | $435,000 | $935,000 | $1,370,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $ 9,075,000 | $951,000 | $ 6,863,000 | $14,744,000 | $21,607,000 | $435,000 | $935,000 | $1,370,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant City of West Bend | | | | | | | | |
| Facilities. . . . . . . . . . | $19,288,000 | $571,000 | $13,927,000 | $9,189,000 | $23,116,000 | $884,000 | $583,000 | $1,467,000 |
| Land . . . . . . . . . . . . | 2,200,000 | - - | 1,263,000 | - - | 1,263,000 | 80,000 | - - | 80,000 |
| Subtotal | $21,488,000 | $571,000 | $15,190,000 | $ 9,189,000 | $24,379,000 | $964,000 | $583,000 | $1,547,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $21,498,000 | $571,000 | $15,190,000 | $ 9,189,000 | $24,379,000 | $964,000 | $583,000 | $1,547,000 |

[a] *This alternative does not include the cost of sludge-related facilities required under Alternative Plan 1. The total present worth over a 50-year analysis period of the additional sludge-related facilities is $2,160,000. The estimated capital cost for construction of the added sludge-related facilities is $1,150,000, with an estimated average annual operation and maintenance cost of $70,000 over the design period 1975-2000.*

*Source: SEWRPC.*

Map 41

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WEST BEND SEWER SERVICE AREAS—UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the existing West Bend treatment plant be upgraded to serve the year 2000 sewer service area. In order to meet the established water use objectives for the Milwaukee River watershed, it will be necessary for this facility to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of the plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River. Both the treatment and discharge alternative and the effluent land application alternative were considered. The treatment and discharge alternative is proposed because it is slightly less costly than the effluent land application alternative, and more closely reflects local planning efforts. Construction of plant additions providing for conventional advanced waste treatment for phosphorus removal and nitrification had been initiated in 1978.

*Source: SEWRPC.*

The second alternative treatment system is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural lands in the Towns of Jackson, Trenton, and West Bend were selected to receive the effluent from the West Bend wastewater treatment facility. These sites would require pumping the effluent about 15,000 feet. The total present worth over a 50-year analysis period of construction and operation of the treatment and conveyance facilities included under Alternative Plan 2 for the West Bend sewer service area is about $24,379,000. The estimated capital cost for constructing the necessary additional treatment facilities is $21,498,000, with an estimated average annual operation and maintenance cost of $571,000 (see Table 103).

On an equivalent annual cost basis, including the cost associated with the sludge-related facilities required under Alternative Plan 1, Alternative Plan 1 is about 3 percent less costly than Alternative Plan 2. In addition to this cost comparison, there are other less tangible, but nevertheless real, factors which should be considered. The ultimate implementation of the treatment and surface water discharge alternative—Alternative Plan 1—should be able to be more readily accomplished, since planning for most of the major components of the alternative is complete and construction underway, and since this alternative represents a continuation of existing practices with the added construction and operational requirements of expansion and an upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would likely be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. The land application alternative requires the commitment of approximately 2,450 acres of land, resulting in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management. The land application alternative also requires the construction of a major conveyance system in order to transport the treatment plant effluent to the land application site. Because of the direct and indirect environmental impacts of the proposed land use changes and conveyance system, Alternative Plan 2 would affect more area and a greater population than would Alternative Plan 1. On the other hand, although there would be a greater wastewater pumping requirement under the land application alternative for conveyance of the wastewater to the land application site, the total energy requirements under Alternative Plan 2 would be less than under Alternative Plan 1 because of the energy required for the higher level of treatment needed under Alternative Plan 1. Other advantages of Alternative Plan 2 are that nutrients would be recycled from the wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, based on the environmental impacts and ease of implementation, Alternative Plan 1—the treatment and surface water discharge alternative—is recommended.

Proposed Plan—Jackson Subarea

In 1975 the wastewater treatment facility serving the Village of Jackson had an average hydraulic design capacity of 0.03 mgd and provided a secondary level of wastewater treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Jackson sewer service area of about 0.72 mgd in 1985 and about 1.24 mgd in the year 2000. This year 2000 design flow is significantly higher than the estimated 1990 design flow of 0.50 mgd anticipated under the regional sanitary sewerage system plan.

In 1976 the Village of Jackson had completed facilities planning for construction of a new wastewater treatment plant on a site east of Jackson on Cedar Creek and adjacent to the existing Libby, McNeill and Libby treatment facility. The proposed facility is designed to provide secondary and tertiary levels of treatment with advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for disinfection prior to discharge to Cedar Creek. The plant is proposed to have an average hydraulic design capacity of 0.87 mgd.

In order to meet established water use objectives for Cedar Creek, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Cedar Creek. The recommendations concerning treatment and discharge to surface waters differ from the recommendations contained in the regional sanitary sewerage system plan with regard to the provision of effluent aeration and the level of phosphorus removal that should be achieved. That plan recommended the provision of secondary waste treatment plus conventional advanced waste treatment for phosphorus removal and nitrification, and auxiliary waste treatment for disinfection. As previously noted, the local facilities planning work has been completed for the Village of Jackson wastewater treatment plant. Because of this existing stage of implementation, the decision to provide advanced waste treatment followed by discharge to the surface waters has been treated as a committed local decision, even though the areawide analysis indicates that, on a generalized basis, an effluent land application alternative may be less costly than providing the levels of treatment needed prior to discharge to surface waters. Future facilities planning efforts designed to evaluate the higher level of phosphorus reduction component of the proposed plan should further consider the land application alternative. The recommended treatment levels and performance standards for the Village of Jackson wastewater treatment plant are set forth in Table 104, and the proposal is shown on Map 42.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities is about $5,724,000. The estimated capital cost for constructing the necessary additional treatment facilities is $3,419,000, with an estimated average annual operation and maintenance cost of $205,300 (see Table 105).

Proposed Plan—Newburg Subarea

In 1975 the wastewater treatment facility serving the Newburg sewer service area had an average hydraulic design capacity of 0.05 mgd, and provided a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity

Table 104

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE JACKSON SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Jackson | 0.72 | 1.24 | Jackson | 3,500 | 6,000 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal[b]<br>Effluent Aeration[b]<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Ammonia-Nitrogen: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

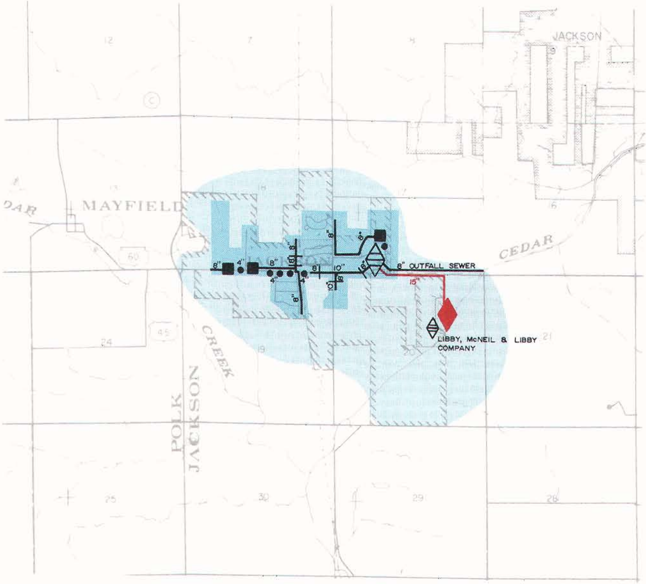
[a] *See Map 39.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus), and auxiliary waste treatment for effluent disinfection.*

*Source: SEWRPC.*

Map 42

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE JACKSON SEWER SERVICE AREA—
UPPER MILWAUKEE RIVER SUBREGIONAL AREA




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE ABANDONED

PROPOSED PUBLIC

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

PROPOSED TRUNK SEWER

EXISTING FORCE MAIN

EXISTING PUMPING STATION

GRAPHIC SCALE

0 1/2 1 MILE

0 2000 4000 6000 8000 FEET

The areawide water quality management plan proposes that the existing Jackson wastewater treatment plant be relocated to a new site and provide sufficient capacity to enable the abandonment of the adjacent private wastewater treatment plant operated by the Libby, McNeill and Libby, Inc. canning plant. In order to meet the established water use objectives for Cedar Creek, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to Cedar Creek. Because of the existing stage of implementation, the areawide plan assumes the surface water discharge alternative. Completed local plans recommend the provision of conventional advanced waste treatment for phosphorus removal (effluent total phosphorus concentration of 1.0 mg/l) and nitrification prior to discharge to Cedar Creek. Future planning efforts should consider increasing the level of phosphorus removal, and should evaluate the alternative of effluent land application.

*Source: SEWRPC.*

for the sewer service area of about 0.24 mgd in 1985 and about 0.45 mgd in the year 2000. This year 2000 design flow is significantly larger than the 0.12 mgd planned 1990 flow anticipated under the regional sanitary sewerage system plan.

In order to meet the established water quality objectives for the Milwaukee River, this facility will need to provide either a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River. The recommendations concerning treatment and discharge to surface waters at the Newburg wastewater treatment plant differ from recommendations contained in the regional sanitary sewerage system plan only with regard to the provision of advanced waste treatment for phosphorus removal. That plan recommended the provision of secondary waste treatment plus auxiliary waste treatment for effluent disinfection.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and effluent land application is considered to be a viable alternative to providing secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection when considering treatment plants the size of the Newburg facility. The recommendation of the areawide water quality management planning program is based on the alternative of treatment and effluent land application, but recognizes the need for more detailed local facility planning to examine alternatives providing for a surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment noted above as needed to meet water quality standards with effluent discharge to the surface waters should be considered. A local facility planning program is presently being conducted to establish wastewater treatment and conveyance needs for the Newburg sewer service area. The recommended treatment levels and performance standards for the Newburg wastewater treatment plant are set forth in Table 106, and the proposal is shown on Map 43.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Newburg sewer service area is about $3,096,000. The estimated capital cost for constructing the necessary additional treatment facilities is $2,456,000, with an estimated average annual operation and maintenance cost of $84,000 (see Table 107).

Alternative Plans—Fredonia-Waubeka Subareas

As already noted, the alternative analysis to be conducted will consider the interconnection of the Fredonia and

Table 105

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE JACKSON SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Jackson . . . . | $3,215,000 | $205,000 | $2,431,000 | $3,161,000 | $5,592,000 | $154,000 | $201,000 | $355,000 |
| Trunk Sewers Village of Jackson . . . . | 204,000 | 300 | 128,000 | 4,000 | 132,000 | 8,000 | 300 | 8,300 |
| Total | $3,419,000 | $205,300 | $2,559,000 | $3,165,000 | $5,724,000 | $162,000 | $201,300 | $363,300 |

*Source: SEWRPC.*

Table 106

WASTEWATER TREATMENT LEVEL AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE NEWBURG SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Newburg | 0.24 | 0.45 | Newburg | 1,400 | 2,400 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 39.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent aeration and disinfection.*

*Source: SEWRPC.*

Table 107

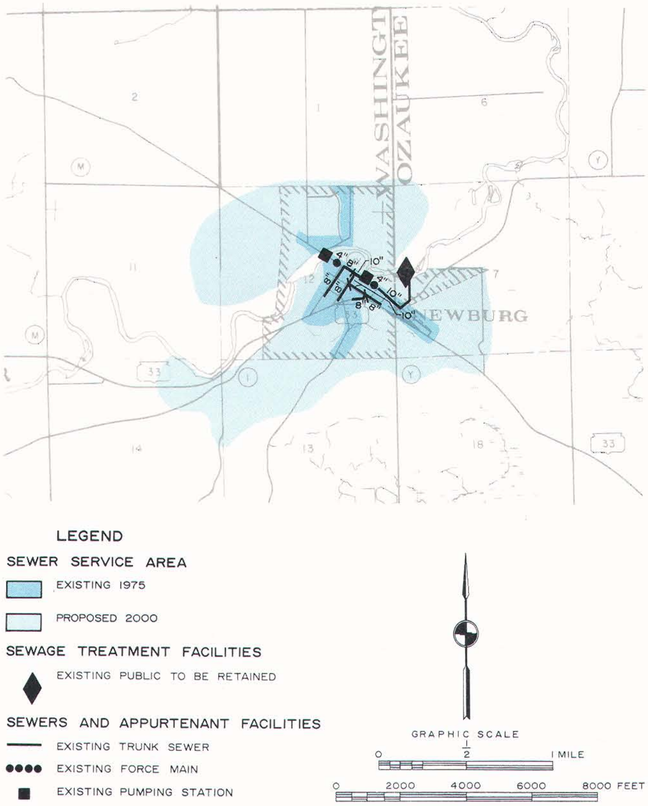
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE NEWBURG SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Newburg | | | | | | | | |
| Facilities . . . . . . . . | $2,294,000 | $84,000 | $1,671,000 | $1,332,000 | $3,003,000 | $102,000 | $85,000 | $187,000 |
| Land. . . . . . . . . . . | 162,000 | - - | 93,000 | - - | 93,000 | 10,000 | - - | 10,000 |
| Subtotal | $2,456,000 | $84,000 | $1,764,000 | $1,332,000 | $3,096,000 | $112,000 | $85,000 | $197,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $2,456,000 | $84,000 | $1,764,000 | $1,332,000 | $3,096,000 | $112,000 | $85,000 | $197,000 |

*Source: SEWRPC.*

Map 43

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE NEWBURG SEWER SERVICE AREA— UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000**




The areawide water quality management plan proposes that the existing Newburg wastewater treatment plant be expanded to meet the anticipated year 2000 needs. In order to meet the established water use objectives for the Milwaukee River, it will be necessary for the plant to be upgraded to provide either land application of plant effluent following the current secondary level of treatment, or secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for disinfection prior to discharge to the Milwaukee River.

*Source: SEWRPC.*

Waubeka subareas for wastewater treatment plant purposes. Two basic alternative plans were formulated. The first alternative plan assumes the provision of two individual wastewater treatment plants to serve the two sewer service areas. The second alternative provides for a single sewage treatment facility at the existing Fredonia wastewater treatment plant site.

In 1975 the wastewater treatment facility serving the Fredonia sewer service area had an average hydraulic design capacity of 0.12 mgd and provided a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Fredonia sewer service area of about 0.34 mgd in 1985 and about 0.41 mgd in the year 2000. This year 2000 design flow is considerably larger than the 0.23 mgd planned 1990 flow developed under the regional sanitary sewerage system plan. Interconnection of the Fredonia and Waubeka sewer service areas will require an average hydraulic design capacity of about 0.54 mgd in the year 2000 at the Fredonia wastewater treatment plant.

In 1978 the Village of Fredonia was in the final stages of the facility planning process to upgrade the existing facility to provide additional capacity for future needs of the Village and the neighboring community of Waubeka. In order to meet established water use objectives for the Milwaukee River, a treatment facility serving either the Village of Fredonia or the Waubeka area will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River. The recommendations concerning treatment and discharge to surface waters differ from the recommendations contained in the regional sanitary sewerage system plan with regard to the provision of phosphorus removal. That plan was based upon a treatment facility serving only the Fredonia area and recommended the provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection.

Based on the generalized analysis described earlier in this chapter, land application is a viable alternative to providing the recommended levels of treatment prior to surface water discharge for plants the size of those considered for the Waubeka and Fredonia sewer service areas. Based upon the preliminary findings of the local facility planning study, the plans developed for the interconnection of the two sewer service areas have incorporated the option of treatment followed by discharge to the surface waters.

Two alternative plans were considered. Alternative Plan 1 provides for separate treatment facilities for the Fredonia and Waubeka area, and Alternative Plan 2 considers interconnection of the two areas for wastewater treatment. The recommended treatment levels and performance standards for both of the alternatives are set forth in Table 108, and the two proposals are shown on Maps 44 and 45.

Under Alternative Plan 1, separate wastewater treatment plants would serve the Village of Fredonia and the Waubeka area. The Village of Fredonia facility would be upgraded and expanded to provide an average hydraulic capacity of 0.41 mgd. The new Waubeka facility would be constructed with a capacity of 0.13 mgd.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities under Alternative Plan 1 for the Fredonia and Waubeka sewer service areas is about $4,213,000. The estimated capital cost for constructing the necessary

Table 108

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE FREDONIA AND WAUBEKA SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| Village of Fredonia | 0.34 | 0.41 | Fredonia | 1,800 | 2,100 | Secondary<br>Advanced[b]<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Waubeka | 0.13 | 0.13 | Waubeka | 600 | 600 | Secondary<br>Advanced[b]<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| Village of Fredonia | 0.47 | 0.54 | Fredonia, Waubeka | 2,400 | 2,700 | Secondary<br>Advanced[b]<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 39.*

[b] *This treatment standard differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River.*

*Source: SEWRPC.*

additional treatment facility at Waubeka and upgrading the existing plant at Fredonia is $2,357,000, with an estimated average annual operation and maintenance cost of $169,000 (see Table 109).

Under Alternative Plan 2, wastewater from the Waubeka sewer service area would be conveyed via a new trunk sewer to an expanded Fredonia wastewater treatment facility. The Fredonia facility would need to be expanded to provide an average hydraulic capacity of 0.54 mgd.

The total present worth over a 50-year analysis period of construction and operation of the recommended treatment facilities under Alternative Plan 2 for the Fredonia and Waubeka sewer service areas is about $3,425,000. The estimated capital cost for constructing the necessary additional treatment facilities is $1,718,000, with an estimated average annual operation and maintenance cost of $137,000 (see Table 109). The costs of both alternatives are based upon the provision of secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River.

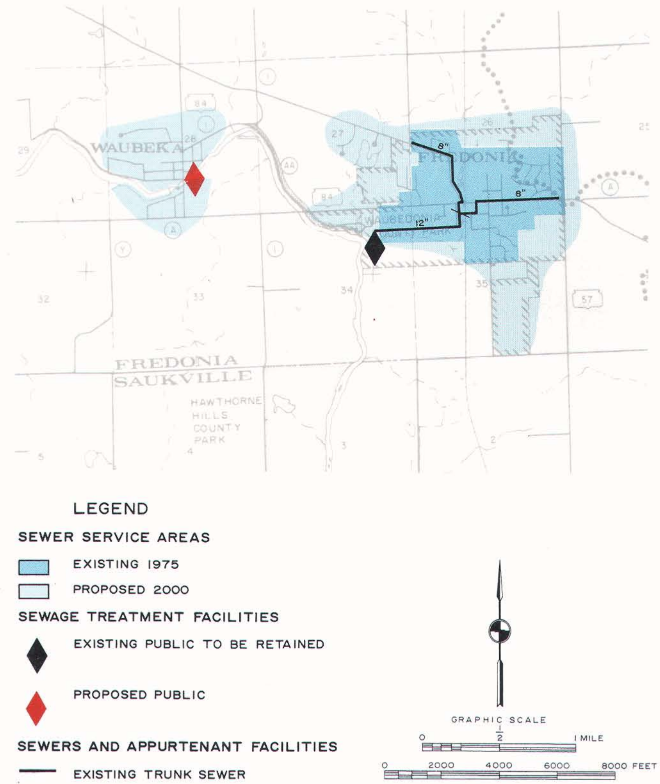
On an equivalent annual basis, Alternative Plan 2 is about 19 percent less costly than Alternative Plan 1. In addition, other less tangible, but nevertheless real, considerations were evaluated in selecting a recommended plan from between these two alternatives. The second alternative has the advantage of providing only one treatment facility, thus avoiding the duplication of staff and related facilities associated with two plants. The monitoring requirements associated with the treatment facilities would also be less under Alternative Plan 2. The second alternative has an inherent disadvantage in that it requires the conveyance of wastewater from the Waubeka sewer service area via a trunk sewer to the Fredonia sewer service area. Thus, because of the environmental impacts of the construction program that would be needed under Alternative Plan 2, that alternative would affect more area and a greater population than would Alternative Plan 1. In addition, under Alternative Plan 2 additional pumping—with its associated energy use—would be required to convey the wastes from the Waubeka sewer service area to the Fredonia sewer system. Based upon all of these considerations, neither alternative is clearly better. However, on the basis of cost and the desire to minimize the proliferation of treatment plants, the second alternative—one wastewater treatment plant to serve both the Fredonia and Waubeka sewer service areas—is recommended.

Proposed Plan—Grafton Subarea

In 1975 the wastewater treatment facility serving the Grafton sewer service area had an average hydraulic design capacity of 1.00 mgd, and provided a secondary level of waste treatment with advanced waste treatment

Map 44

**ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1 FOR THE FREDONIA AND WAUBEKA SEWER SERVICE AREAS— UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000**

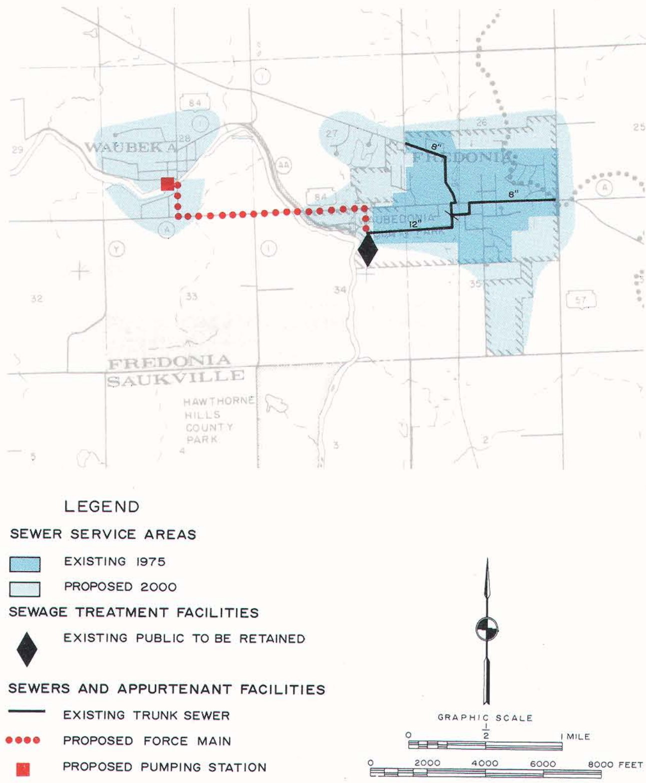



The first alternative plan considered for the Fredonia and Waubeka sewer service areas proposes the establishment of two wastewater treatment facilities, one to serve the Waubeka area and one to serve the Fredonia area. The existing Fredonia wastewater treatment facility would be expanded and provide, in addition to secondary waste treatment, conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for disinfection prior to discharge to the Milwaukee River. A new Waubeka wastewater treatment plant would be constructed on a site along the Milwaukee River and would also provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for disinfection. Land application of plant effluent following a secondary level of treatment is considered a viable alternative to providing advanced waste treatment with discharge to surface waters.

*Source: SEWRPC.*

Map 45

**ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2 FOR THE FREDONIA AND WAUBEKA SEWER SERVICE AREAS— UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000**




The second alternative plan for the Fredonia and Waubeka sewer service areas provides for a single wastewater treatment plant to serve both areas. The existing Fredonia wastewater treatment facility would be expanded to provide service for both the Fredonia and Waubeka sewer service areas. This facility would provide secondary waste treatment, conventional advanced waste treatment for phosphorus removal, and auxiliary waste treatment for disinfection. Based upon cost and the desirability of avoiding proliferation of treatment plants, this alternative is recommended over the alternative of providing separate treatment facilities to serve the Waubeka and Fredonia sewer service areas.

*Source: SEWRPC.*

for phosphorus removal and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Grafton sewer service area of about 1.53 mgd in 1985 and about 2.56 mgd in the year 2000. This year 2000 design flow is higher than the 1.90 mgd planned 1990 flow anticipated under the regional sanitary sewerage system plan.

The Village of Grafton, in conjunction with the City of Cedarburg and the Towns of Cedarburg and Grafton, is in the final stages of a local facilities planning study to determine the existing and future wastewater treatment and conveyance needs for the Cedarburg-Grafton area. The local facility planning program has specifically been designed to deal with wastewater treatment requirements for areas outside of as well as within the designated year 2000 sewer service area. That local facility planning program has concluded that a treatment and discharge alternative is more practical than an effluent land application alternative. Studies conducted under the areawide water quality planning program have indicated that only a very limited amount of open land is suitable for effluent land application in the vicinity of the Cedarburg-Grafton area.

Table 109

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE FREDONIA AND WAUBEKA SEWER SERVICE AREAS: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plants | | | | | | | | |
| Village of Fredonia . . . | $1,409,000 | $113,000 | $1,065,000 | $1,649,000 | $2,714,000 | $ 67,500 | $105,000 | $172,500 |
| Waubeka . . . . . . . . . | 948,000 | 56,000 | 717,000 | 782,000 | 1,499,000 | 45,000 | 50,000 | 95,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $2,357,000 | $169,000 | $1,782,000 | $2,431,000 | $4,213,000 | $112,500 | $155,000 | $267,500 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Fredonia . . . | $1,335,000 | $134,000 | $1,010,000 | $2,040,000 | $3,050,000 | $ 64,000 | $129,000 | $193,000 |
| Trunk Sewer | | | | | | | | |
| Waubeka . . . . . . . . . | 383,000 | 3,000 | 320,000 | 55,000 | 375,000 | 20,000 | 3,500 | 23,500 |
| Total | $1,718,000 | $137,000 | $1,330,000 | $2,095,000 | $3,425,000 | $ 84,000 | $132,500 | $216,500 |

*Source: SEWRPC.*

The local facility planning program evaluated various alternatives with respect to the number and location of treatment facilities needed to sewer the Cedarburg-Grafton area. Alternatives given detailed consideration included the following:

1. The upgrading and expansion of the two existing treatment facilities to serve the year 2000 service area.

2. The abandonment of the existing Grafton plant and construction of a new areawide treatment facility located in the vicinity of the confluence of Cedar Creek with the Milwaukee River. Secondary effluent from the Cedarburg plant would be conveyed to this new plant for advanced waste treatment.

3. The maintenance of the two existing treatment plants to provide secondary treatment, and construction of a new areawide facility to provide advanced waste treatment for the secondary effluent from both the Cedarburg and the Grafton plants.

The preliminary findings of the local facility planning study have indicated that the first alternative—upgrading and expansion of the two existing plants—is the most desirable. The proposed areawide plan has incorporated the recommendations of the local planning effort with regard to the number and location of wastewater treatment plants.

In order to meet the established water quality objectives for the Milwaukee River, the Grafton facility will need to provide a secondary level of waste treatment with conventional advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for effluent disinfection. These recommendations concerning the level of treatment at the Grafton wastewater treatment plant differ from those contained in the regional sanitary sewerage system plan. That plan recommended the provision of secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. The recommendation for nitrification was added based upon an analysis of instream conditions which affect the toxicity of ammonia. The recommended treatment levels and performance standards for the Village of Grafton wastewater treatment plant are set forth in Table 110, and the proposal is shown on Map 46.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Grafton sewer service area is about $6,379,000. The estimated capital cost for constructing the necessary additional treatment facilities is $3,005,000, with an estimated average annual operation and maintenance cost of $264,000 (see Table 111).

Proposed Plan—Cedarburg Subarea

In 1975 the wastewater treatment facility serving the Cedarburg sewer service area had an average hydraulic design capacity of 3.00 mgd, and provided a secondary level of waste treatment with advanced waste treatment

Table 110

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GRAFTON SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Grafton | 1.53 | 2.56 | Grafton | 11,900 | 16,800 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Nitrification<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 39.*

*Source: SEWRPC.*

Table 111

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GRAFTON SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Grafton . . . . | $3,005,000 | $264,000 | $2,292,000 | $4,087,000 | $6,379,000 | $145,000 | $259,000 | $404,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $3,005,000 | $264,000 | $2,292,000 | $4,087,000 | $6,379,000 | $145,000 | $259,000 | $404,000 |

*Source: SEWRPC.*

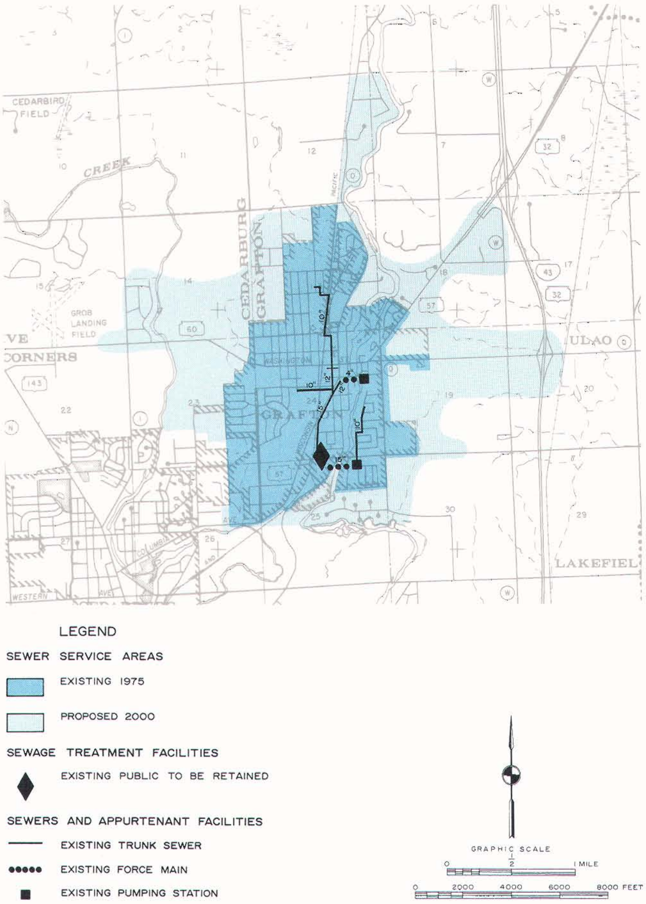
for phosphorus removal and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Cedarburg sewer service area of about 2.31 mgd in 1985 and about 3.07 mgd in the year 2000. This year 2000 design flow is higher than the 2.48 mgd planned 1990 flow anticipated under the regional sanitary sewerage system plan.

As previously noted, the City of Cedarburg, in conjunction with the Village of Grafton and the Towns of Cedarburg and Grafton, is in the final stages of a local facilities planning study to determine the existing and future wastewater treatment and conveyance needs for the Cedarburg-Grafton area. The local facility planning program, as discussed with regard to the Grafton subarea, evaluated various alternatives with respect to the number and location of treatment facilities needed to serve the Cedarburg-Grafton area. The preliminary findings of the local facility planning study indicate that the alternative providing for expansion and upgrading of the two existing plants to serve the year 2000 sewer service area is the most desirable. The local facility planning program has also concluded that the treatment and discharge alternative is more practical than the effluent land application alternative. Studies conducted under the areawide water quality planning program have indicated that only a very limited amount of open land is suitable for effluent land application in the vicinity of the Cedarburg area.

In order to meet the established water quality objectives for Cedar Creek, the Cedarburg wastewater treatment facility will need to provide a secondary level of waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Cedar Creek. The recommendations concerning level of treatment differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. The regional sanitary sewerage system plan recommended

Map 46

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GRAFTON SEWER SERVICE AREA—UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan for the Grafton sewer service area proposes for the expansion of the existing Village of Grafton wastewater treatment plant. The Village would provide advanced waste treatment for nitrification in addition to the current secondary waste treatment, conventional advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River. Detailed local facility planning studies have concluded that the proposed plan providing for expansion and upgrading of the existing Grafton plant is better than alternatives calling for interconnection with the Cedarburg sewer service area for purposes of wastewater treatment.

*Source: SEWRPC.*

that the plant effluent have a total phosphorus concentration of 1.0 mg/l, and that the effluent be conveyed to the Milwaukee River main stem via an outfall sewer.

The preliminary recommendations of the local facility planning program analyses have been based upon Wisconsin Department of Natural Resources standards, which call for similar effluent concentration limits for discharge to either Cedar Creek or the Milwaukee River main stem. These state standards call for an effluent total phosphorus concentration of 1.0 mg/l. Because of the similar initial treatment standards for discharge to Cedar Creek or the Milwaukee River main stem, the construction of an outfall sewer from Cedarburg to the river main stem was not seriously considered in the local study. However, future planning should consider the construction of a trunk sewer as an alternative to the provision of a higher level of phosphorus removal. Each of these alternatives was considered under the areawide plan, and the cost of the two alternatives was comparable—within 10 percent. Because constructing an outfall sewer from the Cedarburg plant site to the confluence of Cedar Creek with the Milwaukee River could adversely affect areas with potential archeological significance, and because of the adverse affect of adding an additional phosphorus load to the Milwaukee River, the areawide plan has been based upon the provision of a high level of phosphorus removal at the Cedarburg plant, with continued discharge of the effluent to Cedar Creek. This proposed plan should be reevaluated as part of the local planning which will be needed to provide for the higher level of treatment. At that time, the results of an archeological survey being conducted as part of the ongoing local facility plan for the Cedarburg-Grafton area will be available.

The recommended treatment levels and performance standards for the Cedarburg treatment plant are set forth in Table 112, and the proposal is shown on Map 47.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Cedarburg sewer service area is about $8,679,000. The estimated capital cost for constructing the necessary additional treatment facilities is $1,713,000, with an estimated average annual operation and maintenance cost of $458,000 over the design period 1975-2000 (see Table 113).

Proposed Plan—Saukville Subarea

In 1975 the wastewater treatment facility serving the Saukville sewer service area had an average hydraulic design capacity of 0.28 mgd, and provided a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Saukville sewer service area of about 0.73 mgd in 1985 and about 1.17 mgd in the year 2000. This year 2000 design flow is significantly higher than the 0.40 mgd planned 1990 flow anticipated under the regional sanitary sewerage system plan.

In 1977 the Village of Saukville had completed facilities planning for upgrading and expansion of the Village's wastewater treatment facility. The proposed wastewater treatment plant is designed to provide secondary waste treatment with conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. The plant is proposed to have an average hydraulic design capacity of about 1.0 mgd.

Table 112

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS–PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE CEDARBURG SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| City of Cedarburg | 2.31 | 3.07 | Cedarburg | 14,700 | 18,300 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Nitrification<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Phosphorus Discharge: 0.1 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>*Fecal Coliform Concentration:* 200/100 ml |

[a]*See Map 39.*

*Source: SEWRPC.*

Table 113

DETAILED ECONOMIC ANALYSIS COST ESTIMATES–PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE CEDARBURG SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant City of Cedarburg . . . . | $1,713,000 | $458,000 | $1,699,000 | $6,980,000 | $8,679,000 | $108,000 | $443,000 | $551,000 |
| Trunk Sewers–None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $1,713,000 | $458,000 | $1,699,000 | $6,980,000 | $8,679,000 | $108,000 | $443,000 | $551,000 |

*Source: SEWRPC.*

In order to meet the established water quality objectives for the Milwaukee River, this facility will need to provide either a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River. The recommendations concerning treatment and discharge to surface waters are the same as those contained in the regional sanitary sewerage system plan.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application is considered to be a viable alternative to providing secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection when considering treatment plants the size of the Saukville facility. However, local facility planning studies have indicated that the treatment and discharge alternative is more practical for the Saukville plant. The recommended treatment levels and performance standards for the Saukville wastewater treatment plant are set forth in Table 114, and the proposal is shown on Map 48.

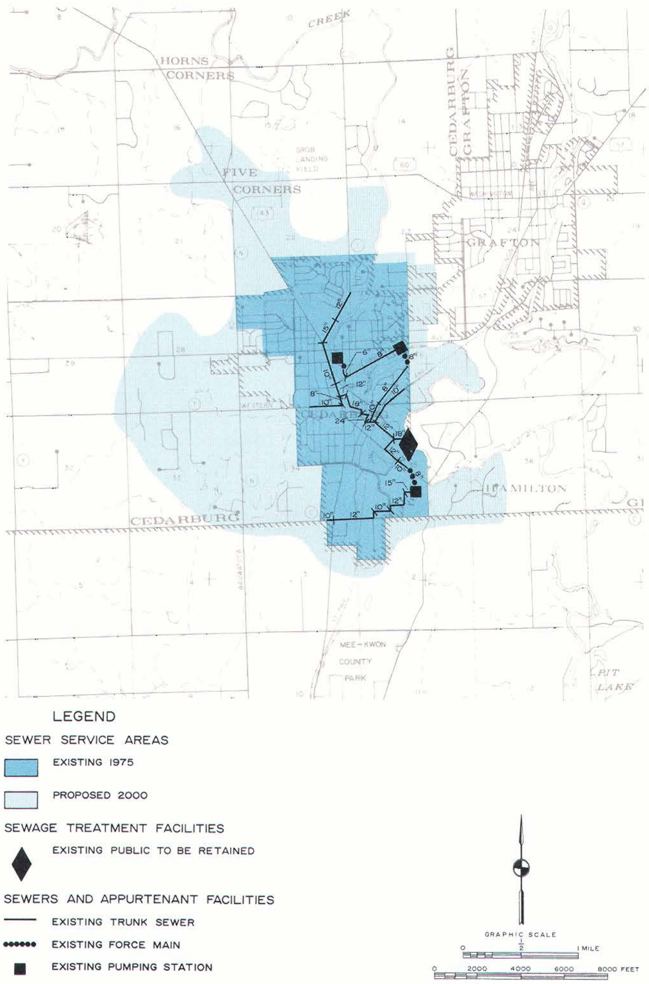
The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Saukville sewer service area is about $3,786,000. The estimated capital cost for constructing the necessary additional treatment facilities is $1,876,000, with an estimated average annual operation and maintenance cost of $155,000 over the design period 1975-2000 (see Table 115). These costs are based upon the provision of secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River.

Private Wastewater Treatment Plants

There are five known private wastewater treatment facilities in the Upper Milwaukee River subregional area which in general serve isolated enclaves of urban land uses and treat wastes which can be accepted in public sanitary sewer systems. These facilities currently discharge rela-

Map 47

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE CEDARBURG SEWER SERVICE AREA— UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000**

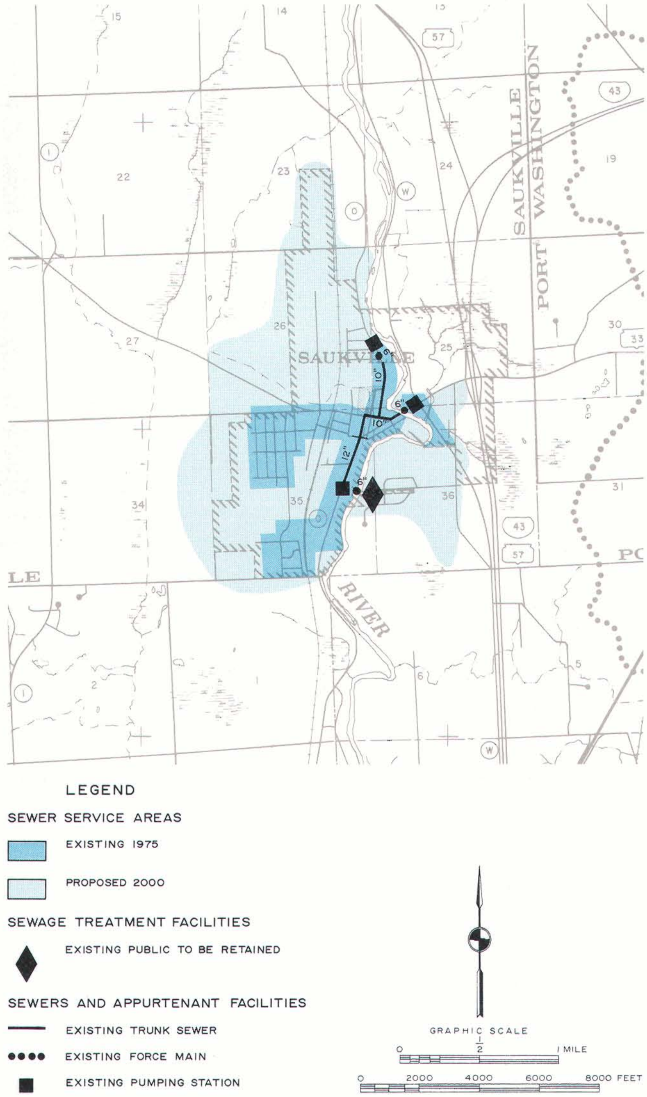



The areawide water quality management plan for the Cedarburg sewer service area proposes the expansion of the existing City of Cedarburg wastewater treatment plant. The City would provide secondary waste treatment, advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a total phosphorus concentration of about 0.1 mg/l—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Cedar Creek. Detailed local facility planning studies have concluded that the proposed plan providing for expansion and upgrading of the existing Cedarburg plant is better than alternatives providing for interconnection with the Grafton sewer service area for purposes of wastewater treatment.

*Source: SEWRPC.*

Map 48

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SAUKVILLE SEWER SERVICE AREA— UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 2000**




The areawide water quality management planning program proposes that the existing Saukville wastewater treatment facility be expanded and provide, in addition to secondary waste treatment, conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to the Milwaukee River.

*Source: SEWRPC.*

tively minor amounts of treated wastewaters to the streams and groundwater in the Upper Milwaukee River subregional area. These five facilities serve the Justro Feed Corporation in the Town of Cedarburg (this facility is not presently—1978—in operation), the S & R Cheese Corporation in the Town of Saukville, the Cedar Lake Rest Home in the Town of West Bend, and the Level Valley Dairy and Libby, McNeill, and Libby—Jackson facility in the Town of Jackson. Four of these facilities, the Justro Feed Corporation, S & R Cheese Corporation, Cedar Lake Rest Home, and Level Valley Dairy lie beyond the proposed year 2000 service areas of the public sanitary sewerage systems discussed above. These facilities, accordingly, must be retained and, as necessary, upgraded to provide a level of waste treatment adequate to meet the water use objectives and standards for streams within the Milwaukee River watershed. The remaining facility lies within a proposed sewer service area in the Upper Milwaukee River subregional area. This facility, the Libby, McNeill, and Libby—Jackson plant,

Table 114

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SAUKVILLE SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Saukville | 0.73 | 1.17 | Saukville | 4,400 | 6,500 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 39.*

*Source: SEWRPC.*

Table 115

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SAUKVILLE SEWER SERVICE AREA: UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Saukville . . . | $1,876,000 | $155,000 | $1,419,000 | $2,367,000 | $3,786,000 | $90,000 | $150,000 | $240,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $1,876,000 | $155,000 | $1,419,000 | $2,367,000 | $3,786,000 | $90,000 | $150,000 | $240,000 |

*Source: SEWRPC.*

should be abandoned and connected to the Village of Jackson sewer system as soon as is feasible.

Based upon the generalized analysis described earlier in this chapter, land application of plant effluent is considered a viable alternative to providing advanced waste treatment prior to discharge to the surface water for facilities the size of the four private plants noted above to be retained. The proposed plan for these plants is based upon the provision of land application of effluent (see Table 116). Should local facility planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharged to the surface waters should be considered.

The estimated present worth of construction and operation of the private wastewater treatment facilities in the Upper Milwaukee River subregional area over a 50-year analysis period is about $1,790,000. The estimated capital cost for constructing the necessary facilities is about $970,000, with an estimated average annual operation and maintenance cost of $67,000.

Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are 14 enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area as shown on Map 39. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are listed in Table 117. In a generalized analysis described earlier in this chapter, the cost of providing public sewerage service to enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that analysis, it was concluded that wastewater treatment for these 12 enclaves should be provided in one of two ways.

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan proposal is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. Nine of the 12 unsewered urban areas are included in this category. These areas are the Town of Cedarburg—Section 15, the Town of Grafton—Section 29, the Town of Port Washington—Section 30,

Table 116

WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| Justro Feed Corporation (not in operation) . . . . . | Town of Cedarburg | Industrial | Process | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| S & R Cheese Corporation . . | Town of Fredonia | Industrial | Process | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Level Valley Dairy . . . . . . | Town of Jackson | Industrial | Process and Cooling | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Cedar Lake Rest Home. . . . | Town of West Bend | Institutional | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |

*Source: SEWRPC.*

Table 117

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE UPPER MILWAUKEE RIVER SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population 1975 | Estimated Resident Population 2000 | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | Ozaukee County | | | |
| 1 | Town of Cedarburg–Section 15 | 256 | 474 | - - |
| 2 | Town of Grafton–Section 29 | 127 | 135 | 0.5 |
| 3 | Town of Grafton–Section 31 | 228 | 250 | 0.6 |
| 4 | Town of Port Washington–Section 30 | 213 | 207 | 0.5 |
| 5 | Deckers Corner | 81 | 132 | 1.6 |
| 6 | Cedarburg/Grafton–Sections 35 and 36 | 271 | 330 | - - |
| | Washington County | | | |
| 7 | City of West Bend–East | 113 | 88 | 0.6 |
| 8 | Town of Jackson–Section 22 | 301 | 321 | 1.4 |
| 9 | Town of Jackson–Section 36 | 287 | 251 | 4.1 |
| 10 | Town of Polk–Section 36 | 119 | 199 | 2.5 |
| 11 | Town of Richfield–Section 12 | 384 | 303 | 0.7 |
| 12 | Big Cedar Lake | 1,731 | 1,563 | 4.5 |
| 13 | Little Cedar Lake | 118 | 134 | 3.5 |
| 14 | Silver Lake | 147 | 143 | 2.5 |
| Total | | 4,376 | 4,530 | - - |

[a] *See Map 39.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

Deckers Corners and Cedarburg/Grafton—Sections 35 and 36 all in Ozaukee County; and City of West Bend-East, the Town of Jackson—Section 22, the Town of Polk—Section 36, and the Town of Richfield—Section 12, all in Washington County.

For the remaining five enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. The five urban enclaves which should consider alternative methods of onsite waste disposal, as well as intensive inspection and maintenance programs for conventional systems, are the Town of Grafton—Section 31 in Ozaukee County, and Town of Jackson—Section 36, Big Cedar Lake, Little Cedar Lake, and Silver Lake in Washington County. In general, areas in this category have soil conditions and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

Sanitary System Flow Relief Devices

In 1975 there were eight known sanitary sewer system flow relief devices in the Upper Milwaukee River subregional area. The proposed plan recommends that local facilities planning efforts include the formulation of plans for the elimination of these sewage flow relief devices.

Other Known Point Sources of Wastewater

There are a total of 21 known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Upper Milwaukee River subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975. It is recommended that these other point sources reduce the effluent concentration of $BOD_5$, ammonia-nitrogen, phosphorus, and fecal coliform to levels generally recommended for the public and private wastewater treatment plants in the Region discharging to the same or similar surface water bodies. In all but three cases no further treatment recommendations were advanced for these other point sources with regard to these constituents. It is also recommended that these point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 118.

The degree of treatment and costs of constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with other pretreatment requirements for existing discharges to public sanitary sewerage systems. However, in order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area, a cost estimate was made of the treatment requirements which appeared to be needed from the limited data available on these point sources. Only three of these point sources appeared to require treatment prior to discharge. One of these three—Dayton Meta-Mold Division—should consider connection to the City of Cedarburg sanitary sewer system. This estimate excludes existing industrial process system modifications designed to reduce pollutant discharge, existing industrial treatment facilities, and existing pretreatment systems utilized for treatment of waste conveyed to public sanitary sewerage systems. The total present worth over a 50-year analysis period of construction and operation of treatment facilities needed to correct existing discharges of industrial wastes is estimated to be about $200,000. The capital cost for constructing the facilities is about $139,000, with an estimated average annual cost of $3,000 over the design period 1975 to 2000.

## SAUK CREEK SUBREGIONAL AREA

The Sauk Creek subregional area includes all of the Sauk Creek watershed, that portion of the Sheboygan River watershed lying within the Region, and minor drainage areas that are directly tributary to Lake Michigan lying generally north of the City of Port Washington. The entire subregional area lies within Ozaukee County. While predominantly rural and agricultural in character, this subregional area contains the City of Port Washington and environs, the Village of Belgium, concentrations of urban development along the shoreline of Lake Michigan in the Town of Belgium, and the newly established Harrington Beach State Park, a major outdoor recreation facility recommended to be established in the adopted regional land use plan and the adopted regional park and open space plan.

*Centralized sanitary sewer service* in the Sauk Creek subregional area was provided by two systems in 1975: those operated by the City of Port Washington and the Village of Belgium. The service areas of these two systems together comprised an area of about 2.8 square miles and served an estimated population of about 10,400 persons. In 1975 there were about 3,100 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the two existing systems are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

### Sewer Service Analysis Areas

A total of three sewer service analysis areas may be identified within the Sauk Creek subregional area (see Table 119). These three sewer service analysis areas are shown on Map 49 and may be described as follows:

Table 118

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION—UPPER MILWAUKEE RIVER SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Upper Milwaukee River Subregional Area | | | | |
| Dayton Malleable Meta-Mold Division. . . | City of Cedarburg | 0.021 | Cedar Creek via Storm Sewer and Drainage Ditch | Five-Day Biochemical Oxygen Demand, Suspended Solids |
| Bermico Company . . . . . . . . . . . . . . | City of West Bend | 0.229 | Milwaukee River | Suspended Solids |
| Culligan Water Conditioning, Inc. . . . . . | City of West Bend | 0.003 | Milwaukee River via Storm Sewer | Five-Day Biochemical Oxygen Demand, Heavy Metals |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Table 119

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE SAUK CREEK SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Population Served | Design Hydraulic Loading (mgd) |
| A | Belgium | 0.36 | 900 | 0.07 | 100 | 1,200 | 0.13 | 1.12 | 1,500 | 0.20 |
| B | Lake Church | - - | - - | - - | 700 | 600 | 0.14[b] | 1.58 | 700 | 0.16[b] |
| C | Port Washington | 2.47 | 9,500 | 1.70 | 300 | 11,500 | 2.12 | 4.36 | 13,600 | 2.56 |
| | Total | 2.83 | 10,400 | 1.77 | 1,100 | 13,300 | 2.39 | 7.06 | 15,800 | 2.92 |

[a] *See Map 49.*

[b] *Includes an estimated flow contribution of 0.01 mgd from Harrington Beach State Park.*

*Source: SEWRPC.*

1. Area A—This area consists of the Village of Belgium and environs. In 1975 sanitary sewer service was provided in this area to about 0.4 square mile, having a total resident population of about 900 persons. The total area anticipated to be served by the year 2000 approximates 1.1 square miles, with a projected resident population of about 1,500 persons. This represents a slight decrease in planned population from the 1,600 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Belgium" sewer service area in the ensuing discussion.

2. Area B—This area consists of the unincorporated village of Lake Church in the Town of Belgium, existing urban development along the shoreline of Lake Michigan in the Town of Belgium, and the Harrington Beach State Park. About 700 persons resided in this area in 1975, but no sanitary sewer service was provided. Because of widespread failure of septic tank systems, the Wisconsin Department of Natural Resources has ordered the installation of centralized sanitary sewer service in the area comprising the unincorporated village of Lake Church. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.6 square miles, with a projected resident population of about 700 persons. This is the same planned population as was forecast for the area for 1990 in the regional sanitary sewerage system plan. In addition, the Harrington Beach State Park is anticipated to provide a design sewage flow of about 0.01 mgd. This subarea is referenced as the "Lake Church" sewer service area in the ensuing discussion.

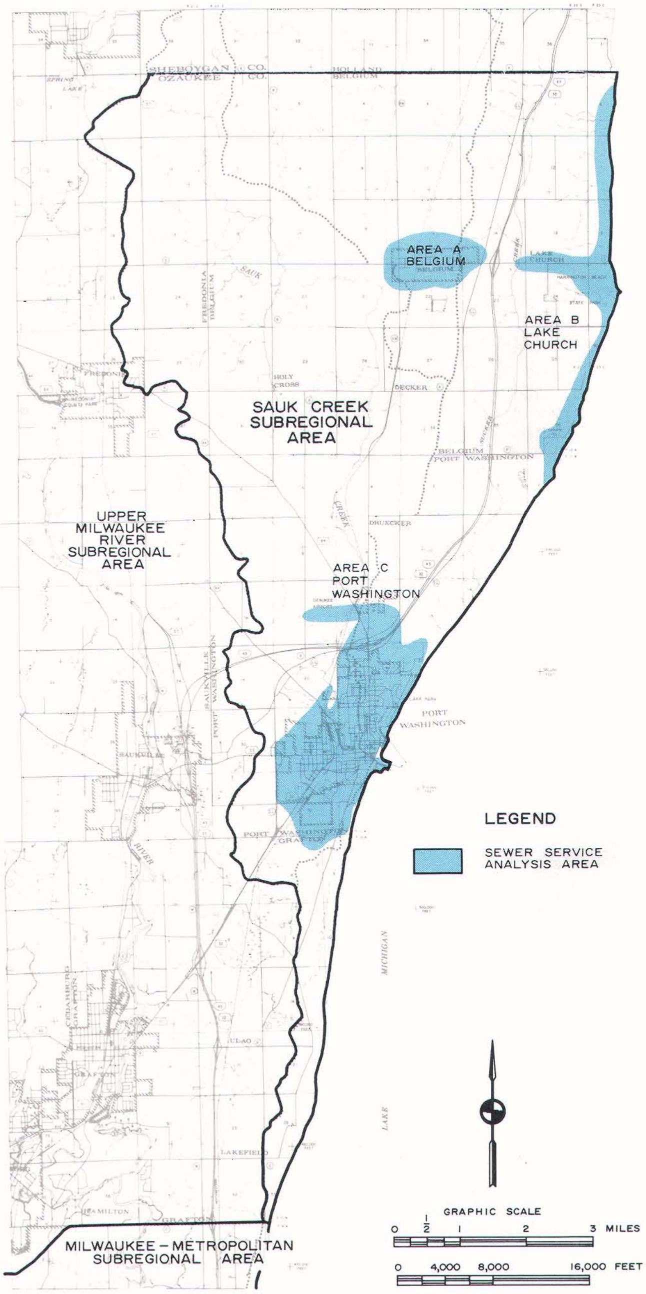
3. Area C—This area consists of the City of Port Washington and environs. In 1975 sanitary sewer service was provided in this area to about 2.5 square miles, having a total resident population of about 9,500 persons. The total area anticipated to be served by the year 2000 approximates 4.4 square miles, with a projected resident population of about 13,600 persons. This represents an increase in the planned population from the 12,400 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Port Washington" sewer service area in the ensuing discussion.

Formulation of Alternatives

As noted earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system plan for the formulation and evaluation of alternative public sanitary sewerage system plans. First, the potential for interconnection of community sanitary sewerage systems was evaluated. One interconnection in the Sauk Creek subregional area—Belgium to Lake Church—was found to be potentially feasible through the application of Wisconsin Department of Natural Resources guidelines concerning distances between and populations of communities. Preliminary economic analyses were then made for that interconnection, with a more detailed analysis conducted for those system alternatives for interconnection which continued to appear feasible following the preliminary analyses. A detailed economic analysis was was made for five alternative plans for the Belgium and Lake Church sewer service areas. The regional sanitary sewerage system plan concluded that the alternative calling for a single treatment facility, located at the Village of Belgium, to serve the Belgium and Lake Church sewer service areas was the most desirable. A detailed

Map 49

SEWER SERVICE ANALYSIS AREAS
SAUK CREEK SUBREGIONAL AREA




Three distinct sewer service analysis areas were identified within the Sauk Creek subregional area. These areas include the Village of Belgium; urban development in the Town of Belgium, including the unincorporated village of Lake Church, nearby Lake Michigan shoreline development, and the Harrington Beach State Park; and the City of Port Washington. Centralized sanitary sewer service was provided in 1975 by the City of Port Washington and the Village of Belgium. The Lake Church area was under orders from the Wisconsin Department of Natural Resources to provide such service. By the year 2000 it is anticipated that about 15,800 persons will reside in these three sewer service areas, which will approximate 7.06 square miles. In 1975 there were about 13,500 persons residing in the Sauk Creek subregional area, of which 10,400 were served by centralized sewer service and 3,100 by onsite sewage disposal systems.

*Source: SEWRPC.*

discussion of the alternative proposals analyzed can be found in Chapter XI of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.

The water quality simulation work developed under the areawide water quality management planning program indicated that higher levels of wastewater treatment with regard to phosphorus removal would be required for the Village of Belgium wastewater treatment plant, which discharges to the Onion River, than had been recommended in the regional sanitary sewerage system plan. In addition, the level of treatment which would be required under an alternative considering discharge to Lake Michigan would be the same or more stringent than the standards utilized under the analysis of alternatives in the regional sanitary sewerage system plan. Based upon generalized cost relationships, the potential need to provide higher levels of treatment would generally be expected to favor a joint treatment alternative, which was recommended in the regional sanitary sewerage system plan. Since the more stringent treatment requirements would economically favor joint treatment, and because a preliminary economic analysis utilizing the revised year 2000 design capacities indicated that joint treatment was less costly in the case of the Belgium and Lake Church sewer service areas, it was concluded that the recommendations of that plan with regard to a joint treatment facility to serve these sewer service areas need not be fully reevaluated. However, because of the higher level of treatment indicated for the discharge at the Village of Belgium plant, the location of the joint treatment facility serving the Belgium and Lake Church sewer service areas was reconsidered, and a new economic analysis was conducted considering an alternative treatment plant with a discharge to Lake Michigan. Accordingly, it was determined that the following sanitary sewerage system plans for the Sauk Creek subregional area should be prepared and evaluated:

1. A proposed plan for the Port Washington sewer service area.

2. Two alternative plans with regard to the treatment facility location for the Belgium and Lake Church sewer service areas.

The recommended plan for the sanitary sewerage systems in the Sauk Creek subregional area as developed under the regional sanitary sewerage system plan is incorporated, with certain modifications indicated as desirable by subsequent system and facilities planning efforts, as an integral part of the areawide water quality management plan recommendations. Results of water quality simulations are presented under the previous section on nonpoint source control element recommendations for the Sheboygan River and Sauk Creek watersheds.

Sanitary sewerage system plans for the three sewer service areas that lie within the Sauk Creek subregional area are described in the following sections.

Proposed Plan—Port Washington Subarea

In 1975 the sewage treatment facility serving the Port Washington sewer service area had an average hydraulic design capacity of about 1.25 mgd, and provided a secondary level of waste treatment plus advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. Disposal of effluent is directly to Lake Michigan within the Port Washington Harbor. It is anticipated that future growth will require an average hydraulic design capacity for the treatment facility serving the Port Washington sewer service area of about 2.12 mgd in 1985 and about 2.56 mgd in the year 2000. This year 2000 design flow is the same as the estimated 1990 design flow anticipated under the regional sanitary sewerage system plan.

The proposed plan for the Port Washington sewer service area includes expansion of the plant and continuation of the current levels of treatment—secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. In addition, the plan proposes the construction of a new outfall sewer to carry the sewage effluent out to Lake Michigan south of the Port Washington Harbor area. The recommendations concerning the level of treatment at the Port Washington treatment plant are the same as those contained in the regional sanitary sewerage system plan. The recommended treatment levels and performance standards for the Port Washington wastewater treatment plant are set forth in Table 120, and the proposal is shown on Map 50.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Port Washington sewer service area is about $7,197,000. The estimated capital cost for constructing the necessary additional treatment facilities is $3,123,000, with an estimated average annual operation and maintenance cost of $308,000 (see Table 121).

Alternative Plans—Belgium and Lake Church Subareas

The regional sanitary sewerage system plan recommended that the Belgium and Lake Church sewer service areas be served by the Village of Belgium wastewater treat-

Table 120

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE PORT WASHINGTON SEWER SERVICE AREA: SAUK CREEK SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| City of Port Washington | 2.12 | 2.56 | Port Washington | 11,500 | 13,600 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a]*See Map 49.*

*Source: SEWRPC.*

Table 121

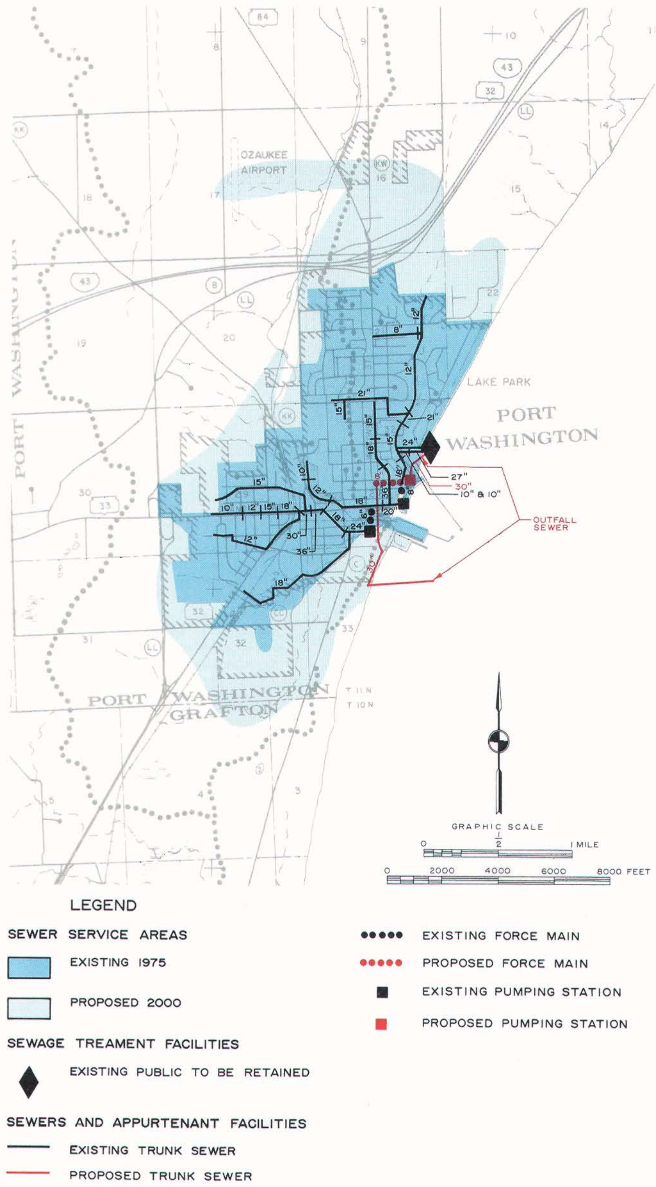
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE PORT WASHINGTON SEWER SERVICE AREA: SAUK CREEK SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant City of Port Washington | | | | | | | | |
| Facilities . . . . . . . . | $2,113,000 | $301,000 | $1,737,000 | $4,710,000 | $6,447,000 | $111,000 | $299,000 | $410,000 |
| Outfall Sewer. . . . . . | 1,010,000 | 7,000 | 625,000 | 125,000 | 750,000 | 39,000 | 8,000 | 47,000 |
| Subtotal | $3,123,000 | $308,000 | $2,362,000 | $4,835,000 | $7,197,000 | $150,000 | $307,000 | $457,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $3,123,000 | $308,000 | $2,362,000 | $4,835,000 | $7,197,000 | $150,000 | $307,000 | $457,000 |

*Source: SEWRPC.*

Map 50

PROPOSED SANITARY SEWERAGE SYSTEM PLAN
FOR THE PORT WASHINGTON SEWER SERVICE AREA—
SAUK CREEK SUBREGIONAL AREA: 2000




In 1975 the City of Port Washington provided secondary waste treatment followed by advanced treatment for phosphorus removal and auxiliary treatment for disinfection, with discharge of effluent directly to Lake Michigan within the harbor area. The proposed plan for Port Washington includes expansion of the plant capacity, continuation of the current levels of treatment, and construction of a new outfall sewer to carry the sewage treatment plant effluent farther out into Lake Michigan south of the harbor area.

*Source: SEWRPC.*

ment facility. As previously noted, alternative analyses were conducted which considered two different locations for a single treatment facility to serve these two sewer service areas. One alternative considered upgrading and expansion of the existing Village of Belgium treatment plant, while the second alternative called for treatment of wastewater from the Belgium and Lake Church sewer service areas at a new treatment plant to be located near Lake Michigan in the Lake Church area. This facility would discharge its effluent directly to Lake Michigan. The recommended treatment levels and performance standards under the two alternatives are set forth in Table 122, and the two proposals are shown on Maps 51 and 52.

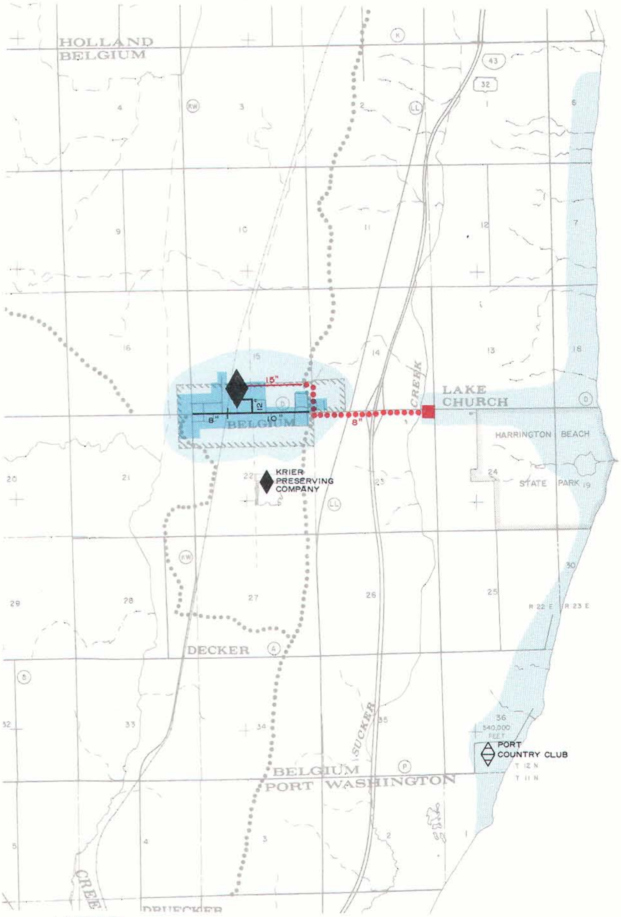
Under Alternative 1, the existing Village of Belgium wastewater treatment plant would be upgraded and expanded to serve the Belgium and Lake Church sewer service areas. In 1975 the sewage treatment facility serving only the Village of Belgium sewer service area had an average hydraulic design capacity of about 0.07 mgd, and provided a secondary level of waste treatment and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth and the addition of the Lake Church sewer service area will require an average hydraulic design capacity for the treatment facility serving the Belgium and Lake Church sewer service areas of about 0.27 mgd in 1985 and about 0.36 mgd in the year 2000.

In order to meet established water use objectives for the Onion River under Alternative Plan 1, the treatment plant located at the Village of Belgium will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for aeration and disinfection prior to discharge to the current receiving stream, a tributary of the Onion River. The recommendations concerning treatment and discharge to the surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the provision of phosphorus removal. The regional sanitary sewerage system plan made no specific recommendation with regard to phosphorus removal, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

Based upon the general analyses described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and effluent land application is considered to be less costly than providing secondary waste treatment followed by a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment. The simulation model studies indicated that the water quality standards for phosphorus cannot be achieved for the

## Map 51

### ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1 FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS—SAUK CREEK SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

EXISTING PRIVATE TO BE RETAINED

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

PROPOSED TRUNK SEWER

PROPOSED FORCE MAIN

PROPOSED PUMPING STATION

GRAPHIC SCALE

0 ½ 1 MILE

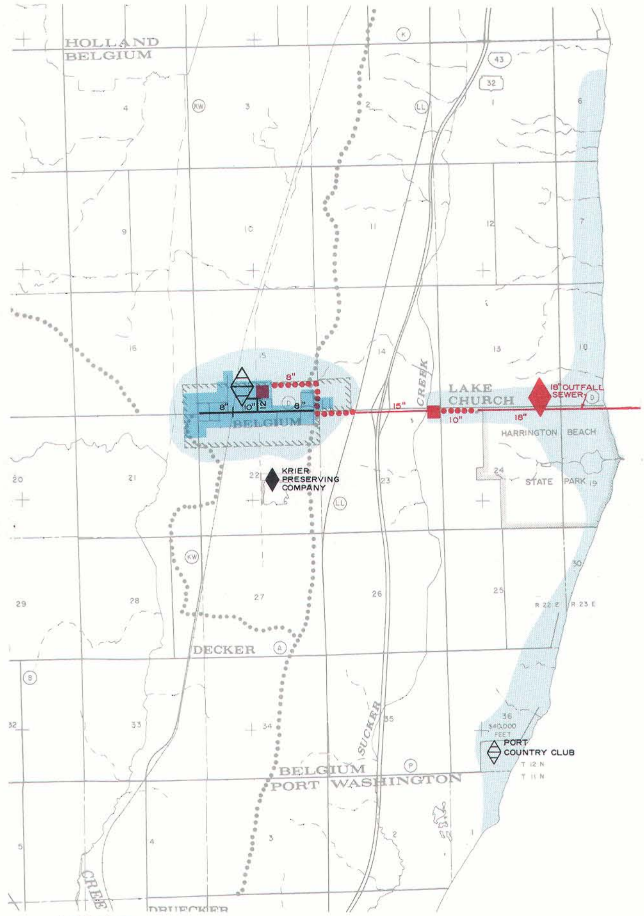
0 2000 4000 6000 8000 FEET

The first alternative plan for the Belgium and Lake Church sewer service areas provides for expansion and upgrading of the existing Belgium wastewater treatment facility to provide wastewater treatment for both the Belgium and Lake Church sewer service areas. This facility would provide secondary waste treatment and auxiliary waste treatment prior to land application of plant effluent, or secondary waste treatment, conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. Wastewater would be conveyed from the Lake Church area to the Belgium sewer service area through the trunk sewer system indicated on the above map.

*Source: SEWRPC.*

## Map 52

### ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2 FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS—SAUK CREEK SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE ABANDONED

PROPOSED PUBLIC

EXISTING PRIVATE TO BE RETAINED

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

PROPOSED TRUNK SEWER

PROPOSED FORCE MAIN

PROPOSED PUMPING STATION

GRAPHIC SCALE

0 ½ 1 MILE

0 2000 4000 6000 8000 FEET

The second alternative plan for the Belgium and Lake Church sewer service areas would provide for a new treatment facility at Lake Church near the Lake Michigan shoreline and would include an outfall to Lake Michigan. The plan would also provide for the abandonment of the existing Belgium wastewater treatment plant. Secondary waste treatment with conventional advanced waste treatment for phosphorus removal followed by auxiliary waste treatment for effluent disinfection would be provided at the new treatment facility prior to discharge to the lake.

*Source: SEWRPC.*

Table 122

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS: SAUK CREEK SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| Village of Belgium | 0.27 | 0.36 | Belgium, Lake Church | 1,900 | 2,200 | Secondary Auxiliary Advanced | Activated Sludge Disinfection Land Application[b] | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| Lake Church | 0.27 | 0.36 | Belgium, Lake Church | 1,900 | 2,200 | Secondary Advanced Auxiliary | Activated Sludge Phosphorus Removal Disinfection | $BOD_5$ Discharge: 15 mg/l Phosphorus Discharge: 1.0 mg/l Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 49.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Onion River.*

*Source: SEWRPC.*

Onion River when conventional advanced waste treatment for phosphorus removal is provided prior to discharge of the effluent to the surface waters. The phosphorus standard can be achieved about 90 percent of the time if land application of effluent is practiced, or if a high level of advanced waste treatment for phosphorus removal is provided prior to discharge to the surface waters and if the appropriate level of diffuse pollutant control is achieved. Accordingly, the effluent land application alternative is incorporated as a treatment system under Alternative Plan 1.

The total present worth over a 50-year analysis period of construction and operation of the treatment and conveyance facilities proposed under Alternative Plan 1 for the Belgium and Lake Church sewer service areas is about $3,060,000. The estimated capital cost for constructing the necessary additional treatment facilities is $2,542,000, with an estimated average annual operation and maintenance cost of $84,000 (see Table 123).

Under Alternative Plan 2, all wastewater from the Belgium and Lake Church sewer service areas would be treated at a new 0.36 mgd wastewater treatment facility to be located near the Lake Michigan shoreline in the Lake Church sewer service area. This facility would discharge its effluent directly to Lake Michigan through an outfall sewer extending 1,000 feet into the lake. This facility would be required to provide secondary waste treatment, advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection. The level of treatment for a waste treatment plant discharge to Lake Michigan recommended under Alternative Plan 2 is the same as that recommended in the regional sanitary sewerage system plan for a similar alternative, except for the provision of phosphorus removal. The regional sanitary sewerage system plan did not recommend phosphorus removal.

The total present worth over a 50-year analysis period of construction and operation of the treatment and conveyance facilities proposed under Alternative Plan 2 for the Belgium and Lake Church sewer service areas is about $3,397,000. The estimated capital cost for constructing the necessary treatment and conveyance facilities is $2,799,000, with an estimated average annual operation and maintenance cost of $91,000 (see Table 123).

A third alternative was also initially considered which is similar to Alternative Plan 1, but would provide for treatment of wastewater from the Belgium and Lake Church sewer service areas at a new treatment facility located at Lake Church on Sucker Creek. The treatment levels required under this alternative would be the same as those required under Alternative Plan 1. In addition, the costs of the alternative would be similar to those of Alternative Plan 1. Alternative Plan 1 would have certain advantages over an alternative calling for discharges to Sucker Creek with regard to implementation since the existing Belgium wastewater treatment facility would continue to be operated under this alternative. Under the third alternative, the Belgium plant would be abandoned, and a new plant operation under a different operating agency would be developed. For this reason, the alternative providing for a treatment facility adjacent to Sucker Creek was considered to be less practical than Alternative Plan 1, and was not considered specifically in the alternative analysis.

Since, on an equivalent annual basis, the cost of implementing Alternative Plan 1 is about 10 percent less

Table 123

**DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BELGIUM AND LAKE CHURCH SEWER SERVICE AREAS: SAUK CREEK SUBREGIONAL AREA**

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plant Village of Belgium | | | | | | | | |
| Facilities. . . . . . . . . . | $1,927,000 | $ 79,000 | $1,409,000 | $1,208,000 | $2,677,000 | $ 89,000 | $77,000 | $166,000 |
| Land . . . . . . . . . . . . | 144,000 | - - | 90,000 | - - | 90,000 | 6,000 | - - | 6,000 |
| Subtotal | $2,071,000 | $ 79,000 | $1,499,000 | $1,208,000 | $2,707,000 | $ 95,000 | $77,000 | $ 72,000 |
| Trunk Sewer Lake Church-Belgium . . . | 471,000 | 4,000 | 291,000 | 62,000 | 353,000 | 18,000 | 4,000 | 22,000 |
| Total | $2,542,000 | $ 84,000 | $1,790,000 | $1,270,000 | $3,060,000 | $113,000 | $81,000 | $194,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant Lake Church | | | | | | | | |
| Facilities. . . . . . . . . . | $1,127,000 | $ 83,000 | $ 852,000 | $1,262,000 | $2,114,000 | $ 54,000 | $80,000 | $134,000 |
| Outfall Sewer . . . . . . . | 1,000,000 | - - | 618,000 | - - | 618,000 | 39,000 | - - | 39,000 |
| Subtotal | $2,127,000 | $ 83,000 | $1,470,000 | $1,262,000 | $2,732,000 | $ 93,000 | $80,000 | $173,000 |
| Trunk Sewer Belgium-Lake Church . . . | 672,000 | 8,000 | 554,000 | 111,000 | 665,000 | 35,000 | 7,000 | 42,000 |
| Total | $2,799,000 | $ 91,000 | $2,024,000 | $1,373,000 | $3,397,000 | $128,000 | $87,000 | $215,000 |

*Source: SEWRPC.*

than the cost of implementing Alternative Plan 2 within the accuracy of the cost-estimating procedures—plan selection must be based upon other less tangible, but nevertheless real, considerations. The first alternative has certain advantages concerning ease of implementation in that a wastewater treatment facility would continue to be operated by the unit of government now providing public sanitary sewer service within the two sewer service areas. Alternative Plan 2 has an advantage in that the level of treatment required is less than that required under Alternative Plan 1, and it thereby requires less manpower and energy. However, the potential future requirement for increased levels of treatment prior to discharge into Lake Michigan is a real consideration. As is noted under the discussion on the Milwaukee metropolitan and Kenosha-Racine subregional areas, higher levels of treatment may be required for the treatment plants serving the Milwaukee metropolitan area and the Cities of Kenosha, Racine, and South Milwaukee as a result of agreements or settlements with the State of Illinois. Conversely, Alternative Plan 1 provides for elimination of all wastewater discharges to the surface waters, provided the effluent land application system is satisfactorily implemented. And, Alternative Plan 2 has a disadvantage in that it requires construction of an outfall in Lake Michigan with the associated environmental impacts. Thus, Alternative Plan 2 would have a greater impact on the environment than would Alternative Plan 1. Based principally on the lesser construction requirement and the ease of implementation, Alternative Plan 1—a wastewater treatment facility located at the Village of Belgium to serve the Belgium and Lake Church sewer service areas with a plant effluent discharge to a land application system—is recommended. Should local facility planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment required to meet water quality standards with the effluent discharged to the surface waters should be considered.

Private Wastewater Treatment Plants

There are three known privately owned sewage treatment facilities in the Sauk Creek subregional area, which in general serve isolated enclaves of urban land uses and treat wastes which can be accepted in public sanitary sewerage systems. These facilities currently discharge relatively minor amounts of treated wastewaters to the streams and groundwaters of the Sauk Creek subregional area. These three facilities serve the Cedar Valley Cheese Factory in the Town of Fredonia, and the Krier Preserving Company and the Port Country Club in the Town of Belgium. Except for the Port Country Club facility, each of these facilities lies beyond the proposed year 2000 service areas of the public sanitary sewerage systems discussed above. These facilities should, therefore, be retained and, as necessary, upgraded to provide a level of waste treatment adequate to meet the water use objectives and standards for the streams in the Sauk Creek subregional area. The Port Country Club facility should be abandoned upon implementation of the proposed sewerage system plan for the Belgium and Lake Church sewer service areas.

As noted earlier in this section, effluent land application facilities are considered a viable alternative to providing advanced waste treatment and auxiliary waste treatment at treatment facilities the size of the private treatment plants in the Sauk Creek subregional area. The proposed plan for these two private plants is based upon the provision of land application of effluent (see Table 124). Should local facility planning efforts indicate that land application of plant effluent is not practical to implement at those private wastewater treatment facilities where that method of treatment is recommended, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharged to the surface waters should be considered.

The estimated present worth of construction and operation of the private wastewater treatment facilities in the Sauk Creek subregional area over a 50-year analysis period is about $1,724,000. The estimated capital cost for constructing the necessary facilities is about $550,000, with an estimated average annual operation and maintenance cost of $83,000.

Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are no existing enclaves of unsewered urban development located outside the proposed year 2000 sewer service area in the Sauk Creek subregional area.

Sanitary Sewer System Flow Relief Devices

In 1975 there were seven sanitary sewer system flow relief devices in the Sauk Creek subregional area. The plan proposes that local facilities planning efforts include the formulation of plans for the elimination of these flow relief devices.

Other Known Point Sources of Wastewater

There are a total of six known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Sauk Creek subregional area. These point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such stream and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of $BOD_5$, ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar receiving water bodies. Thus, in most cases no further treatment recommendations were advanced for these other point sources with regard to these constituents. However, it is recommended that these point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 125.

The degree of treatment and costs of constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with other pretreatment requirements for existing discharges to public sanitary sewerage systems. However, in order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area,

**Table 124**

**WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE SAUK CREEK SUBREGIONAL AREA**

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| Cedar Valley Cheese Factory . . . . . . . | Town of Fredonia | Industrial | Process and Cooling | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Krier Preserving Company . . | Town of Belgium | Industrial | Process | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

*Source: SEWRPC.*

a cost analysis was to be made of the treatment requirements which appeared to be needed from the limited data available on these point sources. Only one point source, the Wisconsin Electric Power Company—Port Washington Power Plant, appeared to require treatment prior to discharge. Costs were not estimated, however, because the wastewater characteristics were bordering the recommended levels, and it was assumed that low-cost process modifications could be effected to satisfactorily reduce the effluent concentrations.

## KENOSHA-RACINE SUBREGIONAL AREA

The Kenosha-Racine subregional area consists of all those parts of Racine and Kenosha Counties lying east of IH 94 except those portions within the Des Plaines River watershed and, therefore, west of the subcontinental divide. This subregional area contains all of the Pike River watershed, a major portion of the Root River watershed, and several minor watersheds that drain directly to Lake Michigan. The area is rapidly urbanizing and includes the central cities of Kenosha and Racine; the Villages of Sturtevant, Elmwood Park, Wind Point, and North Bay; and the highly urbanized Towns of Caledonia, Mt. Pleasant, Somers, and Pleasant Prairie.

Centralized sanitary sewer service in the Kenosha-Racine subregional area was provided by six individual systems in 1975. These systems are the City of Kenosha system, which in addition to serving the city proper provides contract service to the Town of Somers Sanitary District No. 1 and the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, C, and E; the Town of Somers Utility District No. 1 system; the Pleasant Park Utility Company, Inc. system, a privately owned sewer utility classified for planning purposes as a centralized sanitary sewerage system in the regional sewerage system; the City of Racine system, which in addition to serving the city proper provides contract service to the Villages of Elmwood Park and North Bay, the Caledonia Sewer Utility District No. 1, and the Mt. Pleasant Sewer Utility District No. 1; the Village of Sturtevant system; and the North Park Sanitary District system, which serves the Village of Wind Point and parts of the Town of Caledonia, including the Crestview Sanitary District in the Town of Caledonia. Together, these six systems comprised a service area of about 49.4 square miles and served an estimated population of about 221,200 persons. In 1975 there were about 16,900 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the six existing systems are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Table 125

**REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION—SAUK CREEK SUBREGIONAL AREA: 1975**

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituent Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Sauk Creek Subregional Area<br>Wisconsin Electric Power Company—Port Washington Power Plant. | City of Port Washington | 1.80 | Lake Michigan | Suspended Solids |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System report provided under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

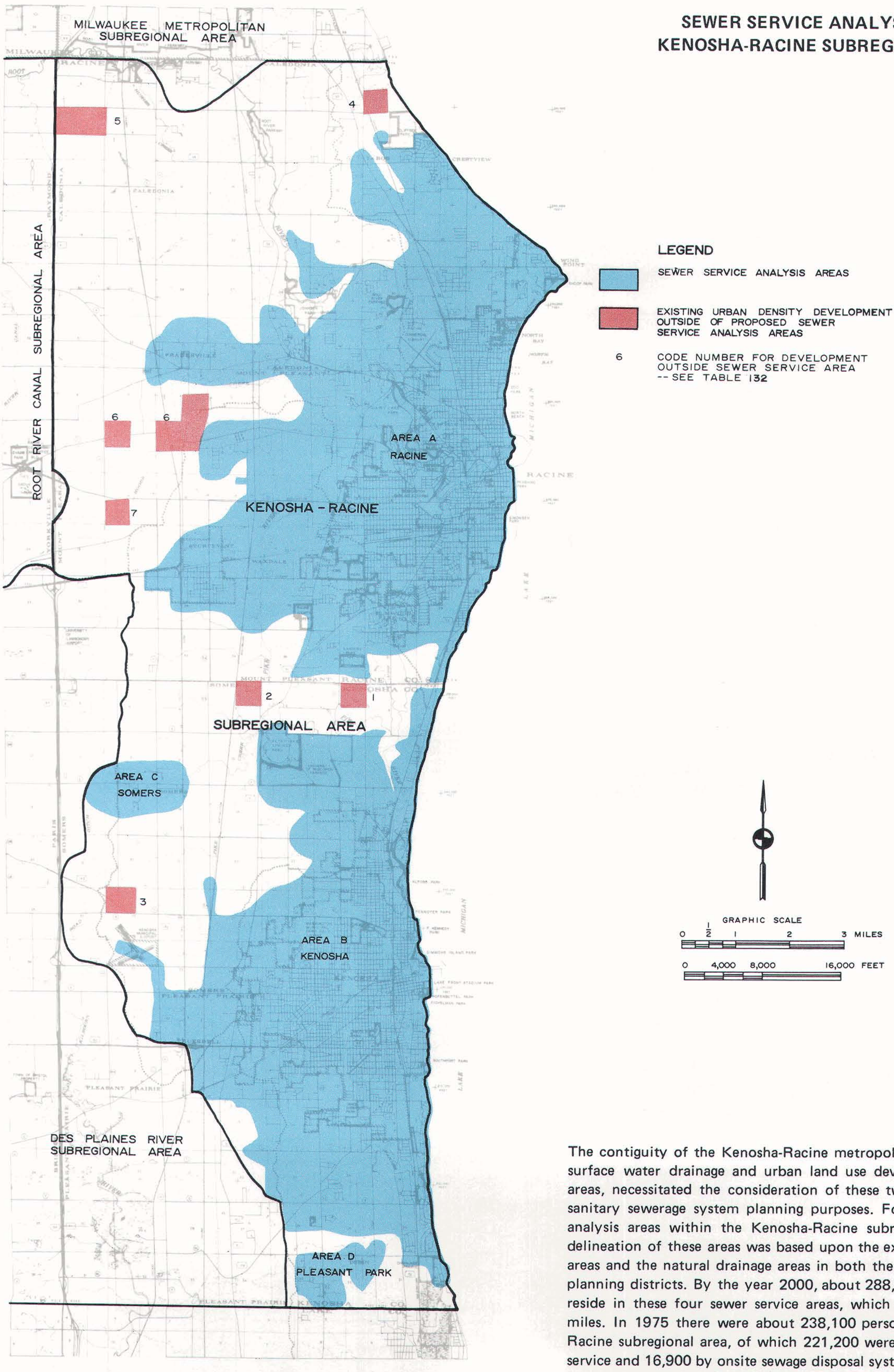
### Sewer Service Analysis Areas

A total of four sewer service analysis areas may be identified within the Kenosha-Racine subregional area (see Table 126). The delineation of these analysis areas was based upon consideration of both the existing sanitary sewer service areas and the natural drainage areas in both the Kenosha and Racine Planning Districts. As rational sewerage system planning areas, these subareas do not correspond directly to existing civil division or special-purpose district boundaries, and should not be confused with such legal entities as discussed in the sewerage system inventories presented in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975 and in Volume One, Chapter V of this report. These sewer service analysis areas are shown on Map 53 and may be described as follows:

1. Area A—This area consists of the City of Racine, the Villages of Elmwood Park, North Bay, Wind Point, and Sturtevant, and major portions of the Towns of Caledonia and Mt. Pleasant, including the existing Crestview and North Park Sanitary Districts and the Caledonia Sewer Utility District No. 1. In 1975 sanitary sewer service was provided in this area to about 32.9 square miles, having a total population of about 130,200 persons. The total area anticipated to be served by the year 2000 approximates 44.0 square miles, with a projected population of about 153,500 persons. This represents a decrease in the planned population from the 220,000 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Racine" sewer service area in the ensuing discussion.
2. Area B—This area consists of the City of Kenosha and portions of the Towns of Pleasant Prairie and Somers, including the Town of Somers Sanitary District No. 1, the Town of Pleasant Prairie Sewer Utility Districts Nos. 1 and 2 and A, B, C, and E, and the University of Wisconsin Parkside campus. In 1975 sanitary sewer service was provided in this area to about 16.0 square miles, having a total resident population of about 89,500 persons. The total area anticipated to be served by the year 2000 approximates 33.9 square miles, with a projected resident population of

Map 53

## SEWER SERVICE ANALYSIS AREAS KENOSHA-RACINE SUBREGIONAL AREA




The contiguity of the Kenosha-Racine metropolitan areas, together with the surface water drainage and urban land use development patterns in these areas, necessitated the consideration of these two areas as a single unit for sanitary sewerage system planning purposes. Four individual sewer service analysis areas within the Kenosha-Racine subregion were identified. The delineation of these areas was based upon the existing sanitary sewer service areas and the natural drainage areas in both the Kenosha and Racine urban planning districts. By the year 2000, about 288,600 persons are expected to reside in these four sewer service areas, which will approximate 81 square miles. In 1975 there were about 238,100 persons residing in the Kenosha-Racine subregional area, of which 221,200 were served by centralized sewer service and 16,900 by onsite sewage disposal systems.

*Source: SEWRPC.*

Table 126

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE KENOSHA-RACINE SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] Letter | Sewer Service Analysis Area[a] Name | Existing 1975 Area Served (square miles) | Existing 1975 Population Served | Existing 1975 Average Hydraulic Loading (mgd) | Existing 1975 Unserved Population Residing in the Proposed 2000 Service Area | Planned 1985 Population Served | Planned 1985 Design Hydraulic Loading (mgd) | Planned 2000 Area Served (square miles) | Planned 2000 Population Served | Planned 2000 Design Hydraulic Loading (mgd) |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Racine | 32.87 | 130,200 | 21.35 | 1,300 | 140,800 | 23.58[b] | 44.00 | 153,500 | 26.24[b] |
| B | Kenosha | 16.03 | 89,500 | 18.40 | 6,600 | 112,600 | 23.25[c] | 33.94 | 128,600 | 26.61[c] |
| C | Somers | 0.29 | 700 | 0.06 | - - | 1,500 | 0.23 | 1.79 | 4,700 | 0.90 |
| D | Pleasant Park | 0.19 | 800 | 0.04 | 300 | 1,800 | 0.25 | 1.24 | 1,800 | 0.25 |
| | Total | 49.38 | 221,200 | 39.85 | 8,200 | 256,700 | 47.31 | 80.97 | 288,600 | 54.00 |

[a] *See Map 53.*

[b] *Includes an estimated contribution from Frank Pure Foods Company and from St. Bonaventure Seminary.*

[c] *Includes an estimated contribution from the Sienadale Motherhouse and from the American Motors Corporation.*

*Source: SEWRPC.*

about 128,600 persons. This represents a decrease in the planned population from that forecast for the area for 1990 in the regional sanitary sewerage system plan. A direct comparison of population cannot be made because this area's 1990 delineation has been combined with portions of other areas in the 2000 delineation. This subarea is referenced as the "Kenosha" sewer service area in the ensuing discussion.

3. Area C—This area consists of a small area surrounding the unincorporated community of Somers. In 1975 sanitary sewer service was provided in this area to about 0.3 square mile, having a total population of about 700 persons. The total area anticipated to be served by the year 2000 approximates 1.8 square miles, with a projected population of about 4,700 persons. This represents a decrease in the planned population from that forecast for 1990 in the regional sanitary sewerage system plan. A direct comparison of population cannot be made because portions of this area's 1990 delineation in the regional sanitary sewerage system plan have now been combined with the Kenosha area year 2000 delineation. This subarea is referenced as the "Somers" sewer service area in the ensuing discussion.

4. Area D—This area consists of a small portion of the Town of Pleasant Prairie currently served by the Pleasant Park Sewer Utility wastewater treatment plant. In 1975 sanitary sewer service was provided in this area to about 0.2 square mile, having a total population of about 800 persons. The total area anticipated to be served by the year 2000 approximates 1.2 square miles, with a projected population of about 1,800 persons. This represents a decrease in the planned population from that forecast for 1990 in the regional sanitary sewerage system plan. A direct comparison of population cannot be made because portions of this area's 1990 delineation in the regional sanitary sewer system plan have now been combined with the Kenosha area year 2000 delineation. This subarea is referenced as the "Pleasant Park" sewer service area in the ensuing discussion.

Summary of Previously Prepared Regional Plan Elements

Previously adopted areawide plan recommendations relating to water quality management and to the provision of centralized sanitary sewer service apply to major portions of the Kenosha-Racine subregional area. Specifically, the Root River watershed plan,[23] prepared and adopted by the Commission in 1966, recommended that, with respect to urban development in the Root River watershed portion of the Kenosha-Racine subregional area, centralized sanitary sewer service be extended from the existing City of Racine system to serve the entire anticipated urban development area. In addition, the Root River watershed plan recommended that the private sewage treatment facility serving the Frank Pure Food Company in the Towns of Caledonia and Mt. Pleasant be abandoned and that the company be connected to the centralized sanitary sewerage system operated by the City of Racine and the Town of Caledonia Sewer Utility District No. 1. With respect to the Kenosha portion of the Kenosha-Racine subregional area, the Commission prepared in 1967, and adopted in 1972, a comprehensive plan for the Kenosha Planning District.[24] This comprehensive plan included a recom-

[23] *See SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed, September 1966.*

[24] *See SEWRPC Planning Report No. 10, A Comprehensive Plan for the Kenosha Planning District, February 1967.*

mendation that the entire anticipated year 2000 urban area within the District be served through appropriate extensions of the existing City of Kenosha sanitary sewerage system. Under this plan recommendation, the existing sewage treatment facilities operated by the Town of Somers Utility District No. 1 and the Pleasant Park Utility Company, Inc. would be abandoned and their tributary service areas connected to the expanded centralized sewer service system. Similarly, the plan recommended that the private sewage treatment facilities serving the American Motors Truck Service Garage in the Town of Somers and the Sienadale Motherhouse in the Town of Pleasant Prairie be abandoned and connected to the Kenosha system as trunk sewer service became available. It is important to note not only that the foregoing sewerage system recommendations contained in both the Root River and Kenosha Planning District comprehensive plans have been adopted by key local units of government, but that these units of government have set in motion a series of plan implementation actions designed to carry out the plan recommendations.

While conducting the regional sanitary sewerage system planning program, the Regional Planning Commission was requested by Racine County, acting on behalf of several local units of government in the Racine portion of the Kenosha-Racine subregional area, to prepare a comprehensive plan for the Racine Urban Planning District. This plan was to have as a major component a sanitary sewerage system element. While initially, the geographical scope of the investigation was to be confined to the area encompassed by the Racine Urban Planning District, several factors intervened during the course of conducting the planning program that dictated the need to expand the geographic scope of the sewerage system investigation to include, as a unit, the entire Kenosha-Racine subregional area. These factors included the interconnection planning requirements set forth by the Wisconsin Department of Natural Resources and the U. S. Environmental Protection Agency, and a local proposal by the Town of Mt. Pleasant to construct a major new sewage treatment plant on the Pike River which would ultimately provide sanitary sewer service to a portion of the Town of Somers. Because these factors conflicted with the sewerage system plan recommendations contained in the adopted Kenosha Planning District plan, it became necessary to reopen the question of sewerage system extensions in the Kenosha Planning District and consider the Kenosha and Racine Planning Districts as a single planning unit under the regional sanitary sewerage system planning program.

As noted earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system plan for the formulation and evaluation of alternative public sanitary sewerage system plans. In the Kenosha-Racine subregional area, all of the sewer service areas were essentially contiguous and it was therefore assumed that a detailed analysis would be required to determine the recommended number and location of public wastewater treatment facilities for the subregional area. A detailed economic analysis was made for five alternatives, which were selected from the many potential alternative sanitary sewerage system plans for the Kenosha-Racine subregional area. The recommended plan included in the regional sanitary sewerage system plan proposed two public wastewater treatment facilities to serve the subregional area. These are the treatment plants operated by the Cities of Kenosha and Racine.

Formulation of Alternatives

Several local planning efforts have taken place which represent a step toward implementation of the recommendations of the regional sanitary sewerage system plan for the Kenosha-Racine subregional area. Local facility planning has been completed for the recommended trunk sewer needed to convey wastewater from the Sturtevant-Mt. Pleasant sewer service area to the Racine wastewater treatment plant. Detailed plans have been developed for construction of this major trunk sewer. Local facility planning has also been initiated by the Cities of Kenosha and Racine which essentially considers all of the year 2000 urban development within the Kenosha-Racine subregional area. As part of that facility planning effort, alternative analyses will likely be conducted to refine the recommendations of the regional sanitary sewerage system plan for wastewater treatment within the areas tributary to the Racine and Kenosha wastewater treatment facilities. In 1977 the Town of Somers Utility District No. 1 initiated construction of an interim addition to its existing wastewater treatment plant, which is planned to bring the capacity of the plant up to a level which will be adequate until trunk sewer capacity for connection to the Kenosha sanitary sewer system is available. To date, the local facility planning effort in the Kenosha area has recommended that the treatment facilities operated by the Town of Somers Sewer Utility District No. 1 and the Pleasant Park Utility Company, Inc. be abandoned and that one wastewater treatment plant—that operated by the City of Kenosha—provide sewage treatment for the entire Kenosha Urban Planning District. Because of the previously committed decisions, the confirmation by local facility planning of the previous recommendations regarding the number and location of treatment plants to serve the Kenosha Urban Planning District, and the concurrent analyses being developed through local facility planning, further formulation and analysis of alternative sanitary sewerage system plans was not considered for this subregional area. In lieu of considering alternatives, the plan for sanitary sewerage systems within the Kenosha-Racine subregional area as developed under the regional sanitary sewerage system plan is incorporated, with certain modifications indicated as desirable by subsequent areawide and local facilities planning efforts, as an integral part of the areawide water quality planning program.

Results of water quality simulations are presented under the previous section on diffuse source control elements for the Pike River and Root River watersheds and Barnes Creek and Pike Creek subwatersheds.

Sanitary sewerage system plans for the four sewer service areas that lie within the Kenosha-Racine subregional area are described in the following sections.

Proposed Plan—Racine Subarea

The recommended plan for the Racine sewer service area proposes that the entire Racine sewer service area be served by the City of Racine wastewater treatment facility, with the abandonment of the existing North Park Sanitary District and Sturtevant wastewater treatment facilities.

In 1975 the wastewater treatment facility serving the City of Racine area had an average hydraulic design capacity of about 23.0 mgd, and provided secondary waste treatment followed by advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to Lake Michigan. Additions to the existing facilities were completed in 1977, bringing the plant average hydraulic capacity up to 30.0 mgd. It is anticipated that connection of the remaining portions of the sewer service area and future growth will require an average hydraulic design capacity for the Racine wastewater treatment plant of about 23.6 mgd in 1985 and about 26.2 mgd in the year 2000. This year 2000 design flow is considerably less than the estimated 1990 design flow of 48.5 mgd anticipated under the regional sanitary sewerage system plan. This change is partially the result of the slightly different method of calculating the design hydraulic loading used in the later study (1975), which considered the existing loading as the principal factor for a facility with relatively limited projected increases in tributary population.

The proposed plan for the Racine sewer service area includes the provision of secondary waste treatment with conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection at the City of Racine wastewater treatment plant. As noted above, provisions for the public wastewater treatment plant element of the recommended plan have essentially been completed. In addition, major improvements to existing trunk sewers would be required to serve the Crestview—in the northern portion of the Racine sewer service area—North Park and Caledonia areas. Finally, a major new trunk sewer would be required to connect the Village of Sturtevant and portions of the Town of Mt. Pleasant in the western and southern portion of the sewer service area to the Racine wastewater treatment plant. The location of the major new trunk sewer and additions is shown on Map 54.

On October 16, 1973, officials of the Cities of Kenosha and Racine signed a settlement to a Lake Michigan pollution lawsuit brought by the State of Illinois which would commit the Cities to provide higher levels of waste treatment at their wastewater treatment facilities and eliminate pollution from combined sewer overflows. The agreement, which is binding on Racine and Kenosha only if all necessary federal and state funds are made available and if all other municipalities discharging effluent to Lake Michigan in the four states bordering Lake Michigan are also required to meet the treatment standards, provides for more stringent effluent limitations than those recommended in the areawide water quality management plan. Table 127 summarizes the effluent limitations agreed to by the Cities of Kenosha and Racine,\and compares these limitations to those recommended herein.

Table 127

COMPARISON OF EFFLUENT LIMITATIONS: KENOSHA-RACINE AGREEMENT AND REGIONAL WATER QUALITY MANAGEMENT PLAN

| Effluent Limitation | Kenosha-Racine Agreement | | | Regional Plan |
|---|---|---|---|---|
| | By 12/31/76 | By 12/31/77 | By 7/1/79 | |
| $BOD_5$ | 20 mg/l (monthly average) | 10 mg/l (monthly average) | 4 mg/l (monthly average) | 15/mg/l (monthly average) |
| Suspended Solids | 20 mg/l (monthly average) | 10 mg/l (monthly average) | 5 mg/l (monthly average) | -- |
| Phosphorus | 1 mg/l (monthly average) | 1 mg/l (monthly average) 90% Removal (annual average) | 1 mg/l (monthly average) 90% Removal (annual average) | 1 mg/l (monthly average) |
| Fecal Coliform | 40/100 ml (Maximum at any time) 20/100 ml (annual average) | 40/100 ml (Maximum at any time) 20/100 ml (annual average) | 40/100 ml (Maximum at any time) 20/100 ml (annual average) | 200/100 ml (monthly average) |

*Source: Cities of Kenosha and Racine, and SEWRPC.*

The City of Racine is presently conducting a detailed facilities planning program to determine wastewater treatment and conveyance needs. A major component of the facility planning program is the sewer system infiltration and inflow studies as well as the analyses of alternatives for eliminating the pollution discharges from the combined sewer overflow system. Phase one of the sewer system evaluation was completed in 1976. The second phase of the sewer system evaluation, the combined sewer overflow pollution abatement study presently (1978) underway and the facility planning considering the analysis of wastewater conveyance and treatment needs, is in the grant application stage. The recommended performance standards for the Racine wastewater treatment plant are set forth in Table 128, and the proposal is shown on Map 54.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Racine sewer service area is about $47,210,000, including the cost of the recently completed treatment plant expansion. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $23,876,000, with an estimated average annual operation and maintenance cost of $2,000,000 (see Table 129). Costs associated with the combined sewer overflow pollution abatement program are included in a separate section of this chapter. As noted above, the level treatment required at the Racine wastewater treatment plant could increase depending on the outcome of a lawsuit brought by the State of Illinois. Compliance with the effluent limitations set forth in the agreement would significantly add to the above-noted costs for the plant.

Table 128

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE RACINE SEWER SERVICE AREA: KENOSHA-RACINE SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| City of Racine | 24.0 | 26.0 | Racine | 140,800 | 153,500 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a]See Map 53.

Source: SEWRPC.

Table 129

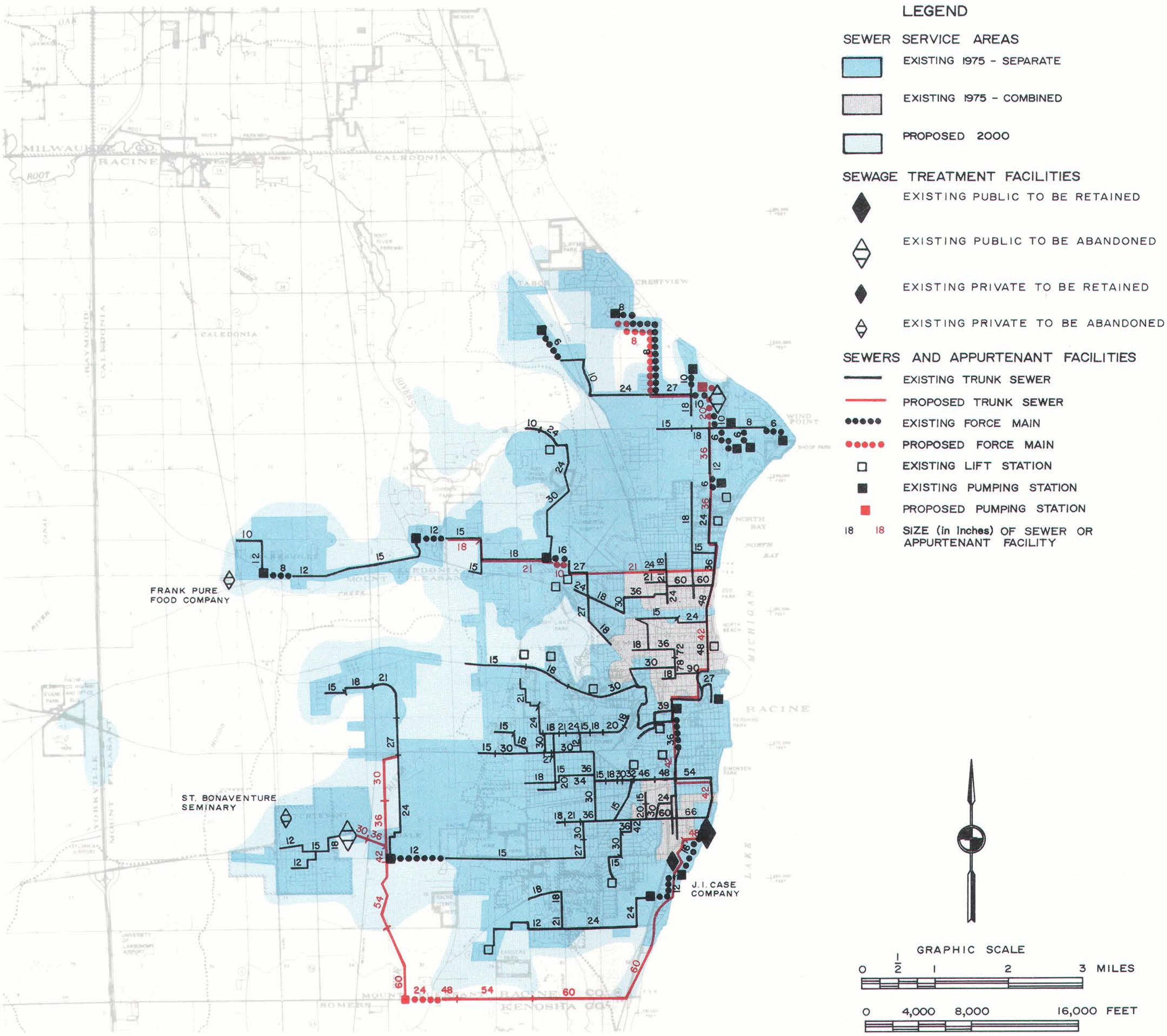
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE RACINE SEWER SERVICE AREA: KENOSHA-RACINE SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant City of Racine . . . . . . . | $ 8,200,000 | $1,962,000 | $ 6,201,000 | $30,668,000 | $36,869,000 | $ 393,000 | $1,946,000 | $2,339,000 |
| Trunk Sewers | | | | | | | | |
| Caledonia, Crestview-North Park to Racine . . | 5,016,000 | 27,000 | 3,147,000 | 361,000 | 3,508,000 | 200,000 | 23,000 | 223,000 |
| Sturtevant to Mt. Pleasant and Sanders Park to Racine . | 10,660,000 | 11,000 | 6,688,000 | 145,000 | 6,833,000 | 424,000 | 9,000 | 433,000 |
| Subtotal | $15,676,000 | $ 38,000 | $ 9,835,000 | $ 506,000 | $10,341,000 | $ 624,000 | $ 32,000 | $ 656,000 |
| Total | $23,876,000 | $2,000,000 | $16,036,000 | $31,174,000 | $47,210,000 | $1,017,000 | $1,978,000 | $2,995,000 |

Source: SEWRPC.

Map 54

## PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE RACINE SEWER SERVICE AREA—KENOSHA-RACINE SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that one public wastewater treatment facility—that operated by the City of Racine—serve the Racine sewer service area by the year 2000. In 1977 the City of Racine wastewater treatment plant provided secondary waste treatment with conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. The plan proposes the continuation of the current levels of treatment. The major trunk sewers necessary for implementation of the plan are shown on the above map.

*Source: SEWRPC.*

The total present worth over a 50-year analysis period of construction and operation of the added treatment facilities needed for the Racine wastewater treatment plant to comply with the State of Illinois agreement is about $14,100,000. The estimated capital cost for constructing the necessary additional treatment facilities is $10,300,000, with an estimated average annual operation and maintenance cost of $400,000.

Proposed Plan—Kenosha, Somers, and Pleasant Park Subareas

The recommended plan for the Kenosha sewer service area proposed that the Somers and Pleasant Park sewer service areas be served by the Kenosha sewage treatment facility, with the concurrent abandonment of the Town of Somers Utility District No. 1 and Pleasant Park Sewer Utility treatment facilities.

In 1975 the wastewater treatment facility serving the Kenosha sewer service area had an average hydraulic design capacity of about 18 mgd, and provided a secondary level of waste treatment followed by advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to Lake Michigan.

It is anticipated that connection with the two abovementioned sewer service areas and future growth will require an average hydraulic design capacity for the Kenosha wastewater treatment plant of about 23.7 mgd in 1985 and about 27.8 mgd in the year 2000. This year 2000 design flow is less than the estimated 1990 design flow of 36 mgd anticipated under the regional sanitary sewerage system plan.

As previously noted, the Town of Somers Utility District No. 1 wastewater treatment plant is presently being expanded to increase the capacity of this interim plant to about 0.13 mgd. The plan is proposed to increase the capacity of the plant until trunk sewer capacity is available from the City of Kenosha.

The proposed plan for the Kenosha, Somers, and Pleasant Park sewer service areas includes the provision of secondary waste treatment with conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection at the City of Kenosha wastewater treatment plant. In addition, major new trunk sewers would be required to connect the Somers and Pleasant Park sewer service areas to the Kenosha wastewater treatment facility. The location of the major new trunk sewers is shown on Map 55.

As noted under the section on the Racine sewer service area, the officials of the Cities of Kenosha and Racine signed a settlement to a Lake Michigan pollution lawsuit brought by the State of Illinois which would commit the Cities to providing higher levels of waste treatment at their wastewater treatment facilities and eliminating pollution from combined sewer overflows. The agreement, which is binding on Racine and Kenosha only if all necessary federal and state funds are made available and if all other municipalities discharging effluent in Lake Michigan in the four states bordering Lake Michigan are also required to meet the treatment standards, provides for more stringent effluent limitations than those recommended in the areawide water quality management plan. Table 127 summarizes the effluent limitations agreed to by the Cities of Kenosha and Racine, and compares these limitations with those recommended herein.

The City of Kenosha is presently conducting a detailed facilities planning program to determine wastewater treatment and conveyance needs. In addition, under the program alternatives means of eliminating the pollution discharges from the combined sewer overflow system will be analyzed. To date, the preliminary facility planning program has recommended the construction of major trunk sewers to convey the wastes from the Somers and Pleasant Park sewer service areas to the Kenosha wastewater treatment plant. The recommendations of that local facility plan with regard to major trunk sewer sizes have been incorporated into the areawide plan. The recommended standards for the Kenosha wastewater treatment plant are set forth in Table 130, and the proposal is shown on Map 55.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Kenosha, Somers, and Pleasant Park sewer service areas is about $46,622,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $21,277,000, with an estimated average annual operation and maintenance cost of $2,033,000 (see Table 131). Costs associated with the combined sewer overflow pollution abatement program are included in a separate section of this chapter. As noted above, the level of treatment required at the Kenosha wastewater treatment plant could increase depending on the outcome of a lawsuit brought by the State of Illinois. Compliance with the effluent limitations set forth in the agreement would significantly add to the above-noted costs for the Kenosha wastewater treatment plant.

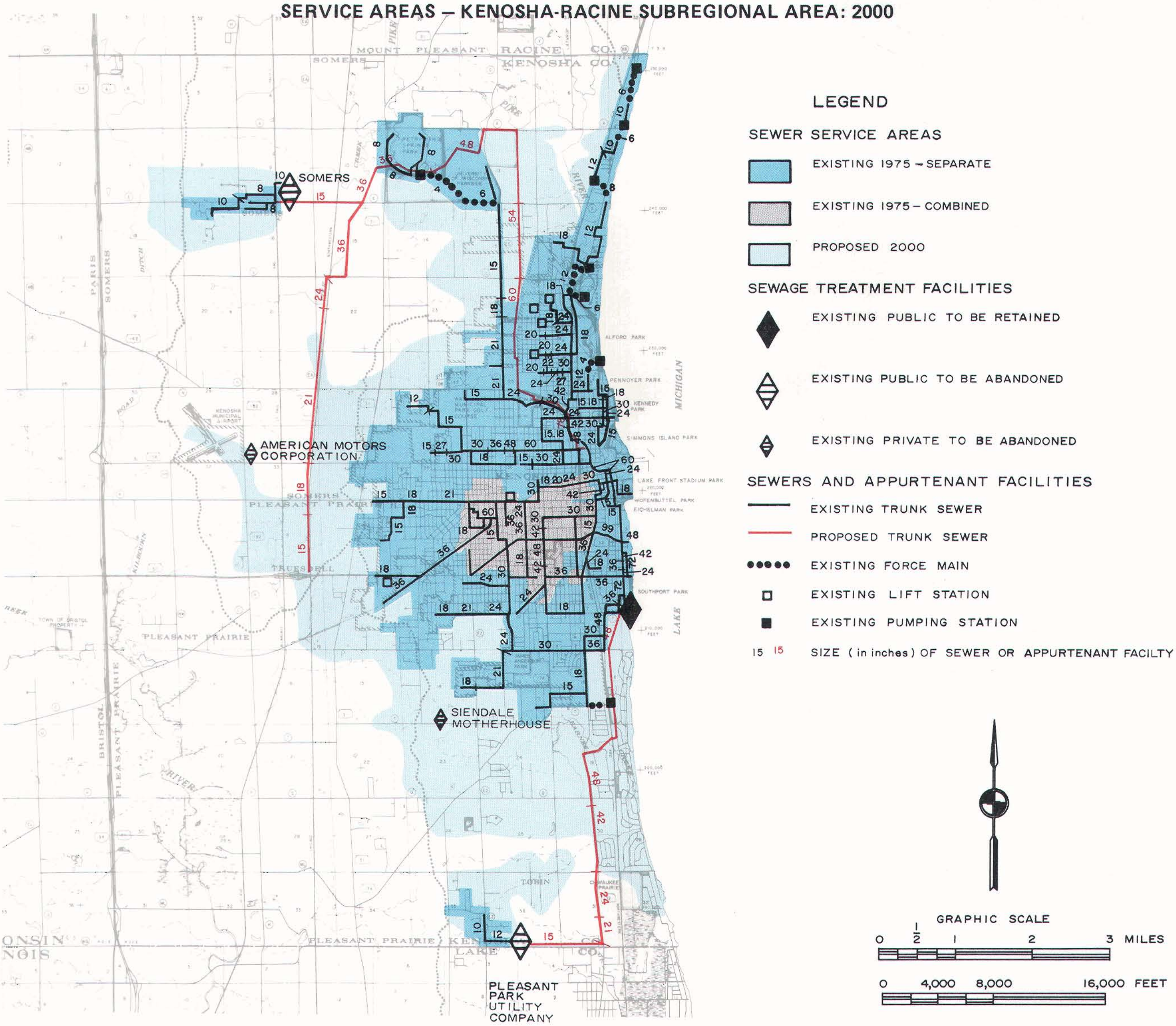
The present worth over a 50-year analysis period of construction and operation of the added treatment facilities needed for the Kenosha wastewater treatment plant to comply with the State of Illinois agreement is about $14,000,000. The estimated capital cost for constructing the necessary additional treatment facilities is $10,000,000, with an estimated average annual operation and maintenance cost of $400,000.

Private Wastewater Treatment Plants

There are five known private wastewater facilities in the Kenosha-Racine subregional area which, in general, serve isolated enclaves of urban land use and treat wastes which can be accepted in public sanitary sewerage systems. These facilities currently discharge relatively minor amounts of treated wastewater to streams, groundwater, and Lake Michigan in the Kenosha-Racine subregional area. These five facilities serve the J. I. Case Company in the Town of Mt. Pleasant; the Sienadale Motherhouse in the Town of Pleasant Prairie, the American Motors Corporation in the Town of Somers, the St. Bonaventure

Map 55

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE KENOSHA, SOMERS, AND PLEASANT PARK SEWER SERVICE AREAS – KENOSHA-RACINE SUBREGIONAL AREA: 2000**




The areawide water quality management plan proposes that one areawide public wastewater treatment facility—that operated by the City of Kenosha—serve the Kenosha, Somers, and Pleasant Park sewer service areas by the year 2000. In 1975 the City of Kenosha wastewater treatment plant provided secondary waste treatment with conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. The plan proposes the continuation of the current level of treatment. The major trunk sewers necessary for implementation of this plan are shown on the above map.

*Source: SEWRPC.*

Seminary in the Town of Mt. Pleasant, and the Frank Pure Food Company in the Town of Caledonia. In 1978 the facility serving the American Motors truck service facility was not in operation. A wastewater holding tank is being utilized to store wastewater prior to removal by tank truck. All five of these facilities lie within the plan year 2000 service areas of the public sanitary sewerage systems discussed above. Consequently, it is proposed that the Sienadale Motherhouse and the American Motors Corporation abandon their treatment facilities and be connected to the Kenosha sewer service area; that St. Bonaventure Seminary abandon its wastewater treatment facility and be connected to the Sturtevant-Mt. Pleasant sewer system; and that the Frank Pure Food Company abandon its wastewater treatment facility and be connected to the Racine sewer service area. The J. I. Case Company facility, although located within the Racine sewer service area, is recommended to be retained due to the nature of its effluent and specialized treatment processes already available. It is proposed that per-

Table 130

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE KENOSHA, SOMERS, AND PLEASANT PARK SEWER SERVICE AREAS: KENOSHA-RACINE SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| City of Kenosha | 24.0 | 28.0 | Kenosha, Somers, Pleasant Park | 115,900 | 135,100 | Secondary Advanced Auxiliary | Activated Sludge Phosphorus Removal Disinfection | $BOD_5$ Discharge: 15.0 mg/l Phosphorus Discharge: 1.0 mg/l Fecal Coliform Concentration: 200/100 ml |

[a]*See Map 53.*

*Source: SEWRPC.*

Table 131

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE KENOSHA, SOMERS, AND PLEASANT PARK SEWER SERVICE AREAS: KENOSHA-RACINE SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant City of Kenosha Facility. . . . . . . . . . | $10,900,000 | $2,023,000 | $ 8,243,000 | $31,741,000 | $39,984,000 | $523,000 | $2,014,000 | $2,537,000 |
| Trunk Sewers Somers to Kenosha . . . . | 7,546,000 | 5,000 | 4,734,000 | 68,000 | 4,802,000 | 300,000 | 4,000 | 304,000 |
| Pleasant Prairie to Kenosha . . . . . . . . | 2,831,000 | 5,000 | 1,776,000 | 60,000 | 1,836,000 | 113,000 | 4,000 | 117,000 |
| Subtotal | $10,377,000 | $ 10,000 | $ 6,510,000 | $ 128,000 | $ 6,638,000 | $413,000 | $ 8,000 | $ 421,000 |
| Total | *$21,277,000* | *$2,033,000* | *$14,753,000* | *$31,869,000* | *$46,622,000* | *$936,000* | *$2,022,000* | *$2,958,000* |

*Source: SEWRPC.*

formance standards for this facility be established based upon specific analyses to be conducted as part of the state permit process. The estimated present worth of construction and operation of this private wastewater treatment facility in the Kenosha-Racine subregional area over a 50-year analysis period is about $809,000. The estimated capital cost for constructing the necessary facilities is about $320,000, with an estimated average annual operation and maintenance cost of $36,000.

Combined Sewer Overflow Abatement Plan

As discussed in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, portions of the Cities of Kenosha and Racine are served by combined sewer systems. In 1975 the area served by such combined systems in the City of Kenosha totaled about 2.2 square miles, or about 14 percent of the total area served by sanitary sewers.[25] The combined sewer overflows were discharged through four outfalls in the City of Kenosha, with the overflows occurring on an average of 20 times per year, and discharging an estimated 260 million gallons of raw sewage to the surface waters of the area annually. In the City of Racine combined sewers served an area of about 2.1 square miles in three separate locations in

[25] *Since the conduct of the Commission inventories in 1975, the City of Kenosha has completed partial separation of the combined sewers for about 0.32 square mile of the total, or about 15 percent of the 2.2-square-mile area referenced. Thus, at the end of 1978, about 1.88 square miles of combined sewer area remained in the City of Kenosha. Similarly, the discharge frequency*

*(footnote continued on following page)*

1975, or about 16 percent of the total area served by sanitary sewers. The combined sewer overflows were discharged through 10 combined sewer outfalls in the City of Racine, with the overflow occurring on an average of 20 times per year, and discharging an estimated 290 million gallons of raw sewage to the surface waters of the area annually. Both the City of Kenosha and the City of Racine have embarked upon sewerage improvement programs designed to effect a greater degree of separation within the combined sewer areas. The City of Racine began its combined sewer separation program in 1935, and the City of Kenosha began its separation program in 1967. The specific areas of the Cities of Kenosha and Racine served by combined sewers are shown on Maps 54 and 55.

Local facility planning study of the combined sewer overflow problem in the City of Kenosha is underway at the present time. The preliminary recommendation of that study is to continue the current program of providing for partial separation of the remaining combined sewers. Such separation would consist of the construction of a new system of storm sewers to convey storm water flow from street inlets and catch basins and the use of the existing combined sewers as partially separated sanitary sewers. This program is estimated to have a capital cost of about $14.1 million, and minimal operating costs.

A preliminary engineering study of the sewer overflow problem is also nearing completion in the City of Racine. The preliminary recommendation of that study is to complete partial separation of the remaining combined sewers. Such separation would consist of the construction of a new system of storm sewers and the conversion of the existing combined sewers to sanitary sewers. The total capital cost of completing this separation program would be about $3.9 million, with minimal operating costs.

Since the areawide water quality management plan is being developed simultaneously with these local combined sewer overflow abatement studies in the Kenosha and Racine urban areas, the proposed plan is based upon the preliminary recommendation of those local studies as set forth above. It is intended that the final approved recommendation of these studies be incorporated into the areawide water quality management plan upon completion and approval of the local studies by the agencies concerned.

Existing Unsewered Urban Development Outside the Proposed Sanitary Sewer Service Area

There are seven enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area as shown on Map 53. The corresponding urban enclave population in 1975 and 2000 and distance to the nearest proposed year 2000 sewer service area are listed in Table 132. In a generalized alternative analysis described earlier in this chapter, the cost of providing public sewerage service to the enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that analysis, it was concluded wastewater treatment for these six enclaves of unsewered urban development should be provided in one of two ways.

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan proposal is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. Three of the seven unsewered urban enclaves were included in this category—the Town of Somers—

Table 132

**EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE KENOSHA-RACINE SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000**

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population | | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | | 1975 | 2000 | |
| | Kenosha County | | | |
| 1 | Town of Somers—Section 1 | 94 | 93 | 0.6 |
| 2 | Town of Somers—Section 3 | 121 | 146 | 0.8 |
| 3 | Town of Somers—Section 29 | 241 | 214 | 1.3 |
| | Racine County | | | |
| 4 | Town of Caledonia—Section 6 | 56 | 45 | 1.0 |
| 5 | Town of Caledonia—Section 7 | 291 | 257 | 1.5 |
| 6 | Town of Mt. Pleasant—Sections 4, 8, and 9 | 465 | 493 | 0.5 |
| 7 | Town of Mt. Pleasant—Section 17 | 122 | 116 | 1.1 |
| Total | | 1,390 | 1,364 | - - |

[a] *See Map 53.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

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*(footnote 25 continued)*

*of 20 times per year and the volume of discharge ranging from 68 to 247 million gallons per year were estimated in the preliminary draft report, Kenosha Service Area Combined Sewer Overflow/Facilities Plan Report transmitted to the City on September 14, 1978, by the consultant, Donohue and Associates, Inc. For the City of Racine, a rough draft report transmitted to the City on October 20, 1978, and entitled Racine Combined Sewer Overflow Report, Racine, Wisconsin, reported an estimated discharge frequency of 20 times per year, and an area served in 1978 of about 1.7 square miles. No estimate of the annual discharge volume was included in the report.*

Section 1, in Kenosha County; and the Town of Caledonia—Section 6 and Section 7 in Racine County.

For the remaining enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. The four urban enclaves which should consider alternative methods of onsite waste disposal and an intensive inspection and maintenance program for conventional systems, as well as the possibility of connections to the public sanitary sewer service area, are the Town of Somers—Section 3 and Section 29 in Kenosha County; and the Town of Mt. Pleasant Sections 4, 8, and 9, and Section 17 in Racine County.

Sanitary Sewer System Flow Relief Devices

In 1975 there were 76 known sanitary or combined sewer system flow relief devices in the Kenosha-Racine subregional area.[26] The proposed plan recommends that local facilities planning efforts include the formulation of plans for the elimination of these sewage flow relief devices.

Other Known Point Sources of Wastewater

There are a total of 21 known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Kenosha-Racine subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams, watercourses, or Lake Michigan. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of five-day biochemical oxygen demand ($BOD_5$), ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar receiving water bodies. Thus, in most cases no further treatment recommendations were advanced for these other point sources with regard to these constituents. However, it is recommended that these point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 133.

[26] *Local sewerage facilities planning activities in the City of Kenosha as documented in the 1978 report, Preliminary Draft—Kenosha Service Area Combined Sewer Overflow/Facilities Plan Report. September 14, 1978, identified 21 additional points of sewage flow relief. A total of 41 crossovers and bypasses were identified in this 1978 study, compared with 20 such devices identified in the 1975 inventory conducted under the areawide water quality management planning program.*

Table 133

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION—KENOSHA-RACINE SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Kenosha-Racine Subregional Area | | | | |
| Frank Pure Food Company. . | Town of Caledonia | 0.013 | Hoods Creek via Drainage Tile | Suspended Solids |
| Twin Disc, Inc.—Racine Street Plant. . . . . . | City of Racine | 0.017 | Root River via Storm Sewer | Phosphorus |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System, reports filed under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: SEWRPC.*

The degree of treatment and costs of constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with other pretreatment requirements for existing discharges to public sanitary sewerage systems. However, in order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area, a cost estimate was made of the treatment requirements which appeared to be needed from the limited data available on these point sources. This estimate excludes existing industrial process system modifications designed to reduce pollutant discharge, existing industrial treatment facilities, and existing pretreatment systems utilized for treatment of waste conveyed to public sanitary sewerage systems. The total present worth over a 50-year analysis period of construction and operation of the treatment facilities needed to correct existing discharges of industrial wastes is estimated to be about $113,000. The capital cost for constructing the facilities is about $108,000, with an estimated average annual cost of $2,000 over the design period 1975 to 2000.

## ROOT RIVER CANAL SUBREGIONAL AREA

The Root River Canal subregional area consists of all that part of the Root River watershed lying west of IH 94 in Racine and Kenosha Counties. The Root River Canal subregional area consists predominantly of rural, agricultural land uses, including several farms devoted to duck raising and butchering. The only incorporated municipality in the Root River Canal subregional area is the Village of Union Grove, which actually straddles the subcontinental divide, lying partially within the Root River watershed and partially within the Des Plaines River watershed. In addition, a major state institution—the Center for the Developmentally Disabled (Wisconsin Southern Colony) operated by the Wisconsin Department of Health and Social Services—is located west of the Village of Union Grove in the Town of Dover.

Centralized sanitary sewer service in the Root River Canal subregional area was provided in 1975 only by the Village of Union Grove to an area of about 1.0 square mile and served an estimated population of 3,200 persons. In 1975 there were also an estimated 8,100 persons residing within the subregional area not served by centralized sanitary sewerage facilities. Of these 8,100 persons, 1,400 were served by the private wastewater treatment facility operated by the Center for the Developmentally Disabled. Specific population, service area, and related characteristics of the Village of Union Grove sanitary sewerage system are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Wisconsin: 1975.

Sewer Service Analysis Areas

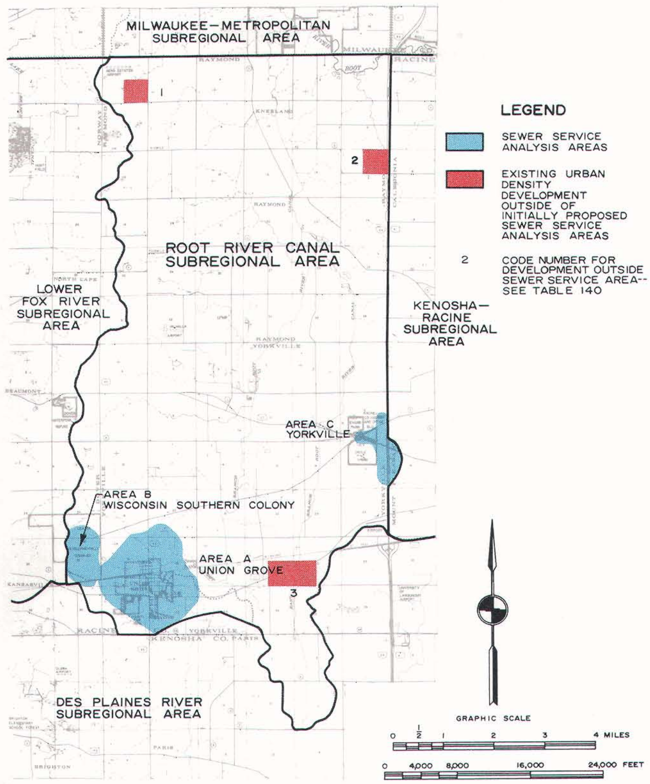
Three sewer service analysis areas may be identified within the Root River Canal subregional area (see Table 134). These three sewer service analysis areas are shown on Map 56 and may be described as follows:

1. Area A—This area consists of the Village of Union Grove and environs. In 1975 sanitary sewer service was provided in this area to about 1.0 square mile, having a total resident population of about 3,200 persons. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 3.0 square miles, with a projected resident population of about 6,400 persons. This represents a decrease in the planned population from the 7,700 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Union Grove" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Center for the Developmentally Disabled (Wisconsin Southern Colony) in the Town of Dover. While the sanitary sewerage system operated by the Wisconsin Department of Health and Social Services to serve this institution is not, strictly speaking, a public centralized sanitary sewerage system, the service area has all the characteristics of a small urban village, and the sewage treatment facility is as large as many facilities serving typical villages throughout the Region. For this reason, and because of its proximity to the Village of Union Grove, the Center has been considered as a separate sewer service area for regional sewerage system planning purposes. The total institution population anticipated to be served by the year 2000 is about 1,900 persons, which closely approximates the planned population of 2,000 persons forecast for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Center for the Developmentally Disabled" sewer service area in the ensuing discussion.

Map 56

SEWER SERVICE ANALYSIS AREAS
ROOT RIVER CANAL SUBREGIONAL AREA




The Root River Canal subregional area consists predominantly of rural, agricultural land uses, including significant amounts of agricultural-related industry such as duck raising and butchering. One urban and one institutional sewer service area are located in this subregion, namely the Village of Union Grove and the Center for the Developmentally Disabled (Wisconsin Southern Colony). One other sewer service area has been identified which presently includes a private wastewater treatment plant serving the Racine County Highway and Park Commission Building in the Town of Yorkville. Wastewater treatment is presently planned to be provided to nearby existing commercial and residential areas, which are generally located on soils unsuited for conventional onsite wastewater treatment systems. Both the Union Grove and the Center's treatment facilities discharge effluent to the West Branch of the Root River Canal. The Racine County Highway and Park Commission Building facility discharges into Hoods Creek. By the year 2000 about 8,400 persons are expected to reside in these three sewer service areas, which will approximate 4.17 square miles. In 1975 there were about 11,300 persons residing in the Root River Canal subregional area, of which 3,200 were served by centralized sewer service, 1,400 were served by a private wastewater treatment facility, and 6,700 were served by onsite sewage disposal systems.

*Source: SEWRPC.*

3. Area C—This area consists of the Racine County Highway and Park Commission Building in the Town of Yorkville and existing surrounding commercial, recreational, and residential land uses which are located in areas unsuited for conventional onsite wastewater disposal systems. While this area was not categorized in the previous regional planning programs as a public sanitary

Table 134

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE ROOT RIVER CANAL SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] Letter | Sewer Service Analysis Area[a] Name | Existing 1975 Area Served (square miles) | Existing 1975 Population Served | Existing 1975 Average Hydraulic Loading (mgd) | Existing 1975 Unserved Population Residing in the Proposed 2000 Service Area | Planned 1985 Population Served | Planned 1985 Design Hydraulic Loading (mgd) | Planned 2000 Area Served (square miles) | Planned 2000 Population Served | Planned 2000 Design Hydraulic Loading (mgd) |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Union Grove. . . . . . . . . . . . | 0.97 | 3,200 | 0.43 | 200 | 4,600 | 0.72 | 2.99 | 6,400 | 1.10 |
| B | Center for the Developmentally Disabled . . . | - - | 1,400[b] | 0.18 | - - | 1,700 | 0.24 | 0.67 | 1,900 | 0.29 |
| C | Yorkville. . . . . . . . . . . . . . . | - - | - - | 0.01[c] | 100 | 100 | 0.07 | 0.51[d] | 100 | 0.07[d] |
| | Total | 0.97 | 4,600 | 0.62 | 300 | 6,400 | 1.03 | 4.17 | 8,400 | 1.46 |

*[a]See Map 56.*

*[b]The population of the Center for the Developmentally Disabled is presently served by a private wastewater treatment facility.*

*[c]Based upon reported 1975 hydraulic loading of the treatment facility serving the Racine County Highway and Park Commission Building.*

*[d]Includes an estimated contribution from the Racine County Highway and Park Commission Building.*

*Source: SEWRPC.*

sewerage system, local plans have been developed which would provide for connection of existing development in the vicinity of the Racine County Highway and Park Commission Building to the private wastewater treatment plant presently operated by the County. The existing development proposed to be connected to the private treatment plant is generally located in areas with soils which are unsuited for conventional onsite wastewater treatment systems. In view of these local plans, the area will contain a mixture of land uses and have the characteristics of a small sewer service area. The population of the area is expected to remain at about 100 persons through the year 2000. This subarea is referenced as the "Yorkville" sewer service area in the ensuing discussion.

Summary of Root River Watershed Plan Recommendations

The Root River watershed plan, as adopted in 1966 by the Regional Planning Commission, included a water pollution abatement plan element pertaining to sewerage facility development in the Root River Canal subregional area. The Root River watershed plan recommended an upgrading of the existing sewage treatment facilities serving the Village of Union Grove, the Center for the Developmentally Disabled, and the Cooper-Dixon Duck Farm (now called C&D Foods, Inc.) Such upgrading was to consist of the provision of additional capacity where necessary, coupled with the provision of higher levels of treatment.[27]

Formulation of Alternatives

As noted earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system plan for the formulation and evaluation of alternative public sanitary sewerage system plans. First, the potential for interconnection of community sanitary sewerage systems was evaluated. The interconnection of Union Grove and the Center for the Developmentally Disabled was found to be potentially feasible through the application of Wisconsin Department of Natural Resources guidelines concerning distances between and population of communities. A preliminary economic analysis was then made for the interconnection, with a more detailed analysis conducted for those system alternatives for interconnection which continued to appear feasible following preliminary analysis. A detailed economic analysis was made for two alternative plans for the Union Grove and Center for the Developmentally Disabled sewer service areas. One alternative provided for a joint treatment facility to serve both areas, while the second alternative, which was ultimately recommended, provided for separate secondary treatment of the wastewater from each service area with provisions for advanced and

[27] *For a more complete description of the water pollution abatement element of the Root River watershed plan, see Chapter XII of SEWRPC Planning Report No. 9, A Comprehensive Plan for the Root River Watershed, June 1966.*

auxiliary waste treatment capacity for both areas at the new Union Grove facility. A detailed discussion of these alternative proposals can be found in Chapter XI of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.

Certain conditions incorporated into the alternative analyses conducted under the regional sanitary sewerage system plan have changed since the time of that study. First, the projected year 2000 design population for the Union Grove sewer service area is about 18 percent lower than the projected 1990 population utilized in the regional sanitary sewerage system plan. Second, it has been determined that the existing outfall sewer from the Center for the Developmentally Disabled treatment plant would not be suitable for conveyance of secondary effluent to the Union Grove treatment facility due to infiltration, as well as to the connections of agricultural field tile to the sewer. For these reasons, the interconnection of the Union Grove and Center for the Developmentally Disabled as analyzed under the regional sanitary sewerage system plan was reconsidered, and an updated economic analysis conducted. With regard to the Yorkville sewer service area, located approximately four miles from the Sturtevant sanitary sewer system which is part of the proposed Racine sewer service area in the Kenosha-Racine subregional area, a plan providing for connection of the system to the Racine sewer service area was considered as an alternative to upgrading and expansion of the existing treatment facility. Accordingly, it was determined that the following sanitary sewerage system plans for the Root River Canal subregional area should be prepared and evaluated:

1. Two alternative plans on the number and location of treatment facilities needed to serve the Union Grove and Center for the Developmentally Disabled sewer service areas.

2. Two alternative plans for the Yorkville sewer service area.

Results of water quality simulations are presented under the previous section on the diffuse source control elements for the Root River watershed.

Sanitary sewerage system plans for the three sewer service areas are described in the following sections.

### Alternative Plans—Union Grove and Center for the Developmentally Disabled Subareas

As noted above, alternative analyses were conducted which considered the interconnection of the Union Grove and Center for the Developmentally Disabled sewer service areas for wastewater treatment plant purposes. Two alternative plans were formulated. The first alternative assumes the provision of two individual treatment plants—one in each sewer service area. The second alternative would provide for consolidation of treatment facilities at the site of the new Union Grove treatment plant, which is scheduled for completion in 1978. The recommended treatment levels and performance standards under the two alternatives are set forth in Table 135, and the two proposals are shown on Maps 57 and 58.

The simulation model studies have indicated that it may not be possible to achieve the water quality standards associated with the warmwater fishery and aquatic life and full recreational use objectives in the Root River Canal even with extensive point and nonpoint source controls. Because of the poor existing water quality in this stream and the critical role of exist in-place pollutants, it was not possible to precisely predict the potential achievement of the high levels of water quality standards under a significantly reduced pollutant loading. Thus, it is recommended that both point and nonpoint source controls be based initially upon the achievement of limited fishery, limited recreation, and minimum use objectives, with further analyses to be conducted to determine whether or not a higher level of water use objectives could be achieved. These analyses will be most suitably conducted following implementation of the controls initially recommended to reduce the existing loadings to the Canal. In order to meet even this lower objective in the Root River Canal, it will be necessary for the treatment plants proposed under each of the two alternative plans to provide a secondary level of wastewater treatment with auxiliary waste treatment for effluent disinfection followed by land application of the effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification and phosphorus, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Root River Canal. In addition, a high level of phosphorus removal producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus is needed to achieve water use objectives established for the Root River main stem downstream of the confluence with the Root River Canal. A warmwater fishery, recreational use standard has been recommended for this downstream section. The regional sanitary sewerage system plan recommended that the treatment facilities serving the Union Grove and Center for the Developmentally Disabled sewer service areas provide secondary waste treatment with conventional advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for effluent aeration and disinfection.

Based upon the general analyses described earlier in this chapter, the provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection followed by effluent land application is considered to be a viable alternative to providing secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to surface waters for facilities the size of the Village of Union Grove and Center for the Developmentally Disabled treatment plants. In both alternative plans, the alternative analyses have been based upon the provision of suitable treatment followed by discharge to

Table 135

**WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE UNION GROVE AND CENTER FOR THE DEVELOPMENTALLY DISABLED SEWER SERVICE AREAS: ROOT RIVER CANAL SUBREGIONAL AREA**

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| Village of Union Grove. . . . . . | 0.72 | 1.10 | Union Grove | 4,600 | 6,400 | Secondary | Activated Sludge | $BOD_5$ Discharge: 15.0 mg/l |
| | | | | | | Advanced | Nitrification | Ammonia-Nitrogen Discharge: 1.5 mg/l |
| | | | | | | | Phosphorus Removal | Phosphorus Discharge: 0.1[b] mg/l |
| | | | | | | Auxiliary | Aeration | Dissolved Oxygen in Effluent: 6.0 mg/l |
| | | | | | | | Disinfection | Fecal Coliform Concentration: 200/100 ml |
| Center for the Developmentally Disabled . . . | 0.24 | 0.29 | Center for the Developmentally Disabled | 1,700 | 1,900 | Secondary | Activated Sludge | $BOD_5$ Discharge: 30.0 mg/l |
| | | | | | | Auxiliary | Disinfection | Fecal Coliform Concentration: 200/100 ml |
| | | | | | | Advanced | Land Application[b] Spray Irrigation | - - |
| Alternative Plan 2 | | | | | | | | |
| Village of Union Grove. . . . . . | 0.96 | 1.39 | Union Grove Center for the Developmentally Disabled | 6,300 | 8,300 | Secondary | Activated Sludge | $BOD_5$ Discharge: 15.0 mg/l |
| | | | | | | Advanced | Nitrification | Ammonia-Nitrogen Discharge: 1.5 mg/l |
| | | | | | | | Phosphorus Removal | Phosphorus Discharge: 0.1[b] mg/l |
| | | | | | | Auxiliary | Aeration | Dissolved Oxygen in Effluent: 6.0 mg/l |
| | | | | | | | Disinfection | Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 56.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system recommendations, which included the provision of secondary waste treatment with conventional advanced waste treatment for phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Root River Canal.*

*Source: SEWRPC.*

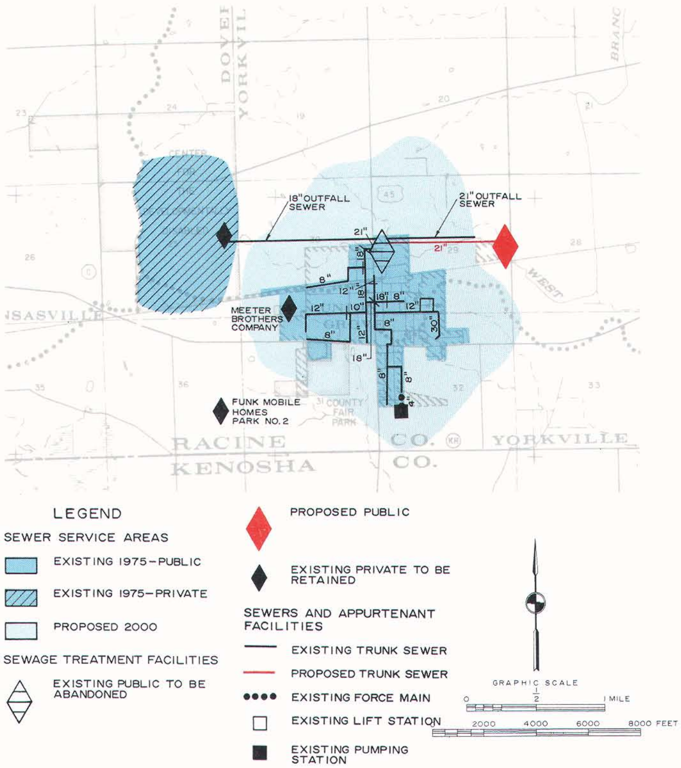
the surface waters for the Union Grove treatment plant since the construction of most major components of the needed facilities is presently underway. Under Alternative Plan 1, which also includes a treatment facility at the Center for the Developmentally Disabled, treatment followed by an effluent land application system was utilized in the alternative analysis for that plant, since this alternative was found to be less costly at the systems level and since there is no previous commitment to the construction of advanced waste treatment facilities.

Under Alternative Plan 1, the existing Village of Union Grove wastewater treatment plant would be expanded and upgraded to serve the Union Grove sewer service area. In 1975 the sewage treatment facility serving the Village of Union Grove had an average hydraulic design capacity of 0.30 mgd, and provided a secondary level of waste treatment. Union Grove is currently constructing a new treatment facility, which is scheduled for completion in 1978. This new facility is designed to provide secondary waste treatment, as well as advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. As previously noted, the treatment facilities and the influent sewer have been designed so that additions and modifications to accept additional wastewater from the Center for the Developmentally Disabled sewer service area could be accomplished at a future date. The new facility has been designed with an average hydraulic design capacity of 1.0 mgd. It is anticipated that future growth will require an average hydraulic design capacity for the Union Grove sewer service area of about 0.72 mgd in 1985 and about 1.10 mgd in the year 2000. This year 2000 design flow is less than the estimated 1990 design flow of 1.43 mgd anticipated under the regional sanitary sewerage plan.

The Center for the Developmentally Disabled treatment facility would also be upgraded under Alternative Plan 1. In 1975 the sewage treatment facility serving the Center for the Developmentally Disabled had an average hydraulic design capacity of 0.45 mgd and provided a secondary level of waste treatment. It is

Map 57

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1 FOR THE UNION GROVE AND CENTER FOR THE DEVELOPMENTALLY DISABLED SEWER SERVICE AREAS–ROOT RIVER CANAL SUBREGIONAL AREA: 2000

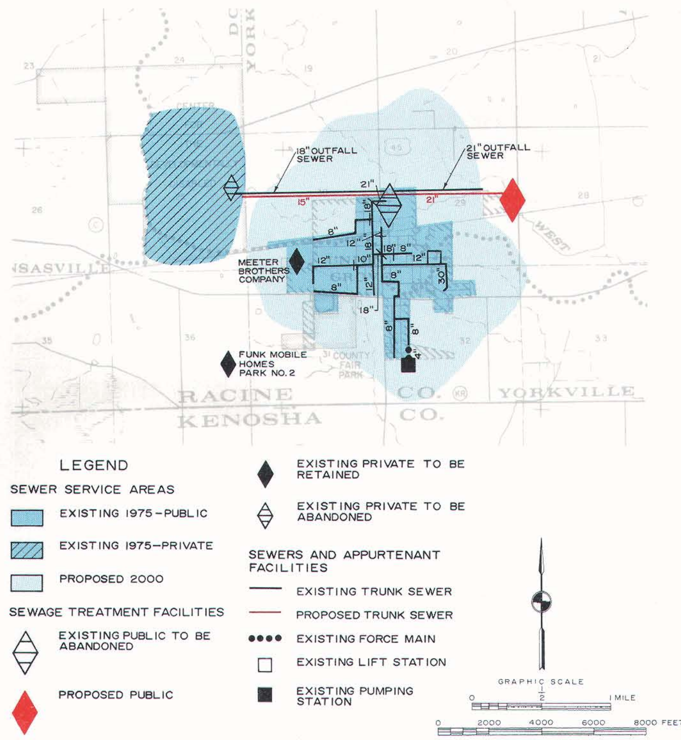



The first alternative plan for providing service to the Union Grove and Center for the Developmentally Disabled sewer service areas proposes the continued operation of two wastewater treatment facilities, with relocation of the existing Union Grove plant to a new site located on the West Branch of the Root River Canal. The new Union Grove plant would provide secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the West Branch of the Root River Canal. The existing Center for the Developmentally Disabled treatment facility would be upgraded to provide secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application of plant effluent.

*Source: SEWRPC.*

Map 58

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2 FOR THE UNION GROVE AND CENTER FOR THE DEVELOPMENTALLY DISABLED SEWER SERVICE AREAS–ROOT RIVER CANAL SUBREGIONAL AREA: 2000




The second alternative plan for providing service to the Union Grove and Center for the Developmentally Disabled sewer service areas proposes consolidation of wastewater treatment for the two areas at the new Union Grove wastewater treatment plant located on the West Branch of the Root River Canal. The new Union Grove plant would provide secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection. Waste would be conveyed from the Center for the Developmentally Disabled treatment plant to the existing Union Grove treatment plant site and be combined with the wastewater from Union Grove prior to being conveyed to the new plant site through a common trunk sewer.

*Source: SEWRPC.*

anticipated that the future resident population of the Center for the Developmentally Disabled sewer service area will require an average hydraulic design capacity of about 0.24 mgd in 1985 and about 0.29 mgd in the year 2000. This year 2000 design flow is less than the estimated 1990 design flow of 0.40 mgd anticipated under the regional sanitary sewerage system plan.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Union Grove and Center for the Developmentally Disabled service areas is about $7,240,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $4,360,000, with an estimated average annual operation and maintenance cost of $268,000 (see Table 136).

Under Alternative Plan 2, the Union Grove and Center for the Developmentally Disabled sewer service areas would consolidate their wastewater treatment at the site of the new Union Grove wastewater treatment plant, which is presently under construction. Wastewater would be conveyed from the Center for the Developmentally Disabled plant site to the site of the old Union Grove wastewater treatment plant via a new trunk sewer. The wastes from the two service areas would then be combined and conveyed to the new plant site through a new 21-inch trunk sewer which is presently under construction, and which has been designed to handle the flow from both sewer service ares. It is anticipated that future growth will require an average hydraulic design capacity for the Union Grove and Center for the Developmentally Disabled sewer service areas of about 0.96 mgd in 1985 and 1.39 mgd in the year 2000.

Table 136

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE UNION GROVE AND CENTER FOR THE DEVELOPMENTALLY DISABLED SEWER SERVICE AREAS: ROOT RIVER CANAL SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Union Grove. . . . . | $2,854,000 | $192,700 | $2,150,000 | $2,986,000 | $5,136,000 | $137,000 | $189,700 | $326,700 |
| Center for the Developmentally Disabled | | | | | | | | |
| Facility . . . . . . . . . . . . | 1,210,000 | 75,000 | 755,000 | 1,165,000 | 1,920,000 | 48,000 | 12,000 | 60,000 |
| Land . . . . . . . . . . . . . . | 110,000 | - - | 63,000 | - - | 63,000 | 4,000 | - - | 4,000 |
| Subtotal | $1,320,000 | $ 75,000 | $ 818,000 | $1,165,000 | $1,983,000 | $ 52,000 | $ 12,000 | $ 64,000 |
| Subtotal—Treatment Plants | $4,174,000 | $267,700 | $2,968,000 | $4,151,000 | $7,119,000 | $189,000 | $201,700 | $390,700 |
| Trunk Sewers | | | | | | | | |
| Village of Union Grove. . . . . | 186,000 | 300 | 117,000 | 4,000 | 121,000 | 7,000 | 300 | 7,300 |
| Total | $4,360,000 | $268,000 | $3,085,000 | $4,155,000 | $7,240,000 | $196,000 | $202,000 | $398,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Union Grove. . . . . | $4,160,000 | $234,000 | $3,145,000 | $3,583,000 | $6,728,000 | $199,000 | $227,000 | $426,000 |
| Trunk Sewers | | | | | | | | |
| Village of Union Grove. . . . . | 210,000 | 400 | 132,000 | 6,000 | 138,000 | 8,000 | 400 | 8,400 |
| Center for the Developmentally Disabled . . . | 186,000 | 300 | 117,000 | 4,000 | 121,000 | 7,000 | 300 | 7,300 |
| Subtotal | $ 396,000 | $ 700 | $ 249,000 | $ 10,000 | $ 259,000 | $ 15,000 | $ 700 | $ 15,700 |
| Total | $4,536,000 | $234,700 | $3,394,000 | $3,593,000 | $6,987,000 | $214,000 | $227,700 | $441,700 |

*Source: SEWRPC.*

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Union Grove and Center for the Developmentally Disabled sewer service areas is about $6,987,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $4,536,000, with an estimated average annual operation and maintenance cost of $234,700 (see Table 136).

On an equivalent annual basis, Alternative Plan 2 would be about 3 percent less costly to implement than Alternative Plan 1. However, other less tangible, but nevertheless real, considerations were also evaluated in the alternative analysis. Alternative Plan 2 has the advantage of providing only one treatment facility to serve the two sewer service areas, thus avoiding the duplication of staff and related facilities associated with two plants. The monitoring requirements associated with the treatment facilities would also be less under Alternative Plan 2. Alternative Plan 1 has the advantage of continued use of the existing Center for the Developmentally Disabled treatment facility, which was remodeled in 1968. Alternative Plan 1 also has certain advantages concerning the probability of implementation in that wastewater treatment facilities would continue to be operated by the two units of government now providing public sanitary sewer service in the Root River Canal subregional area. Based upon all these considerations, neither alternative is clearly better. However, principally on the basis of the desirability of consolidating treatment service and lower operating costs, Alternative Plan 2—the consolidation of waste treatment for the Union Grove and Center for the Developmentally Disabled sewer service areas—is recommended.

Alternative Plans—Yorkville Subarea

As noted above, alternative analyses were conducted which considered the interconnection of the Yorkville sewer service area to the Sturtevant portion of the Racine sewer service area, with ultimate conveyance to the Racine wastewater treatment facility in the Kenosha-Racine subregional area. Two alternative plans were formulated. The first alternative assumes continued operation along with the needed expansion and upgrading of the treatment facility in the Yorkville sewer service area. The second alternative plan would provide for connection of the Yorkville sewer service area to the Sturtevant sewerage system for conveyance to the Racine wastewater treatment plant. The recommended sewage treatment levels and performance standards under the two alternatives are set forth in Table 137, and the two proposals are shown on Maps 59 and 60.

In order to meet established water use objectives for Hoods Creek under Alternative Plan 1, the treatment plant located at the Racine County Highway and Park Commission Building will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for aeration and disinfection prior to discharge to Hoods Creek. The regional sanitary sewerage system plan did not contain specific recommendations with respect to the level of treatment for this facility. However, it was generally recommended in that plan that the facility be upgraded to meet the established water use objectives and supporting standards for the streams within the Root River watershed.

In 1975 the wastewater treatment facility serving the Racine County Highway and Park Commission Building and the county golf course was considered a private plant and had an average hydraulic design capacity of 0.01 mgd and provided a secondary level of waste treatment. As noted above, the Town of Yorkville has formed a sanitary district and proposed the establishment of a public sanitary sewerage system to serve commercial, industrial, and residential development generally located along IH 94, CTH C, CTH A, and STH 20 in the vicinity of the Racine County Highway and Park Commission Building. The expansion of the area tributary to the Racine County Highway and Park Commission Building treatment plant will resolve existing onsite wastewater treatment problems that now necessitate the use of holding tanks in the area. Alternative Plan 1 recommends the expansion and upgrading of the existing wastewater treatment facility serving this area. This area had not been recommended to be served by a public sanitary sewerage system under the regional sanitary sewerage system plan, or under the newly adopted land use plan. Based principally upon local plans, the areawide water quality management plan proposes that public sanitary sewers be provided, but that this system principally serve existing development to provide relief from existing onsite wastewater treatment problems. Under Alternative Plan 1, the existing development located within the sewer service area will require an average hydraulic design capacity of about 0.07 mgd.

Based upon the general analyses described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and effluent land application is considered to be less costly than providing secondary waste treatment with a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment. Accordingly, the effluent land application alternative is incorporated as a treatment system under Alternative Plan 1.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Yorkville sewer service area is about $776,500. The estimated capital cost for constructing the necessary additional treatment facility is $735,000, with an estimated average annual operation and maintenance cost of $15,400 (see Table 138).

Table 137

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE YORKVILLE SEWER SERVICE AREA: ROOT RIVER CANAL SUBREGIONAL AREA

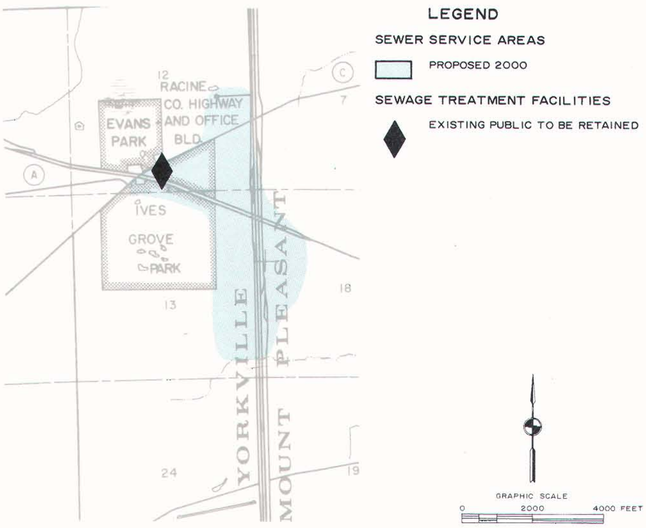
| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1<br>Town of Yorkville . . | 0.07 | 0.07 | Yorkville | 100 | 100 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application | $BOD_5$ Discharge: 30.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Alternative Plan 2<br>City of Racine. . . . . | 24.0 | 26.0 | Racine, Yorkville | 140,900 | 153,600 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Phosphorus Discharge: 1.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a]See Map 56.

Source: SEWRPC.

## Map 59

### ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1 FOR THE YORKVILLE SEWER SERVICE AREA— ROOT RIVER CANAL SUBREGIONAL AREA: 2000

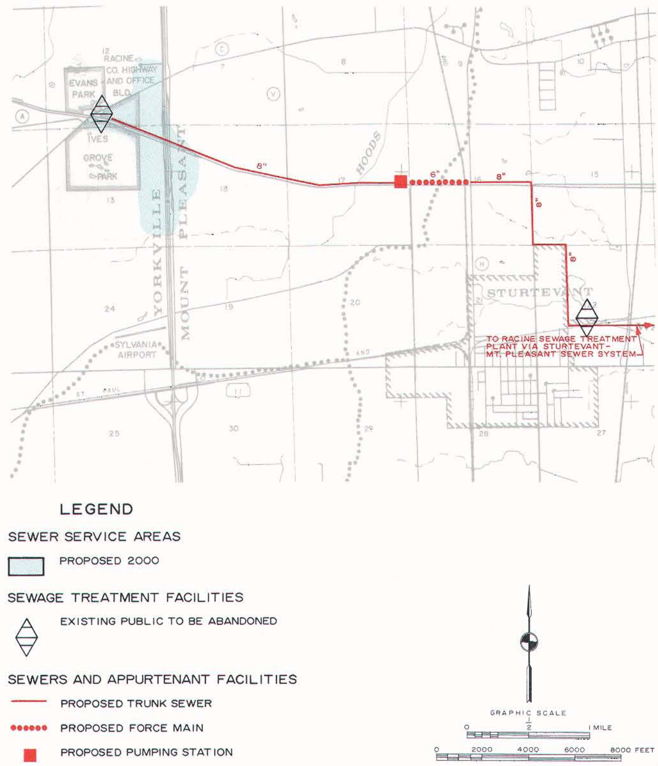



The first alternative plan for providing service to the Yorkville sewer service area proposes the expansion and upgrading of the existing private wastewater treatment plant now serving the Racine County Highway and Park Commission Building and the adjacent golf course and reclassification of this plant as a public facility. Public sanitary sewer service is proposed to be provided to serve existing commercial, industrial, and residential development in the vicinity of the existing plant in order to resolve existing onsite wastewater disposal problems that now necessitate the use of holding tanks in portions of the area. The wastewater treatment plant is proposed to provide a secondary level of treatment followed by land application of plant effluent.

*Source: SEWRPC.*

## Map 60

### ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2 FOR THE YORKVILLE SEWER SERVICE AREA— ROOT RIVER CANAL SUBREGIONAL AREA: 2000




The second alternative plan for providing service to the Yorkville sewer service area proposes the abandonment of the existing private wastewater treatment plant now serving the Racine County Highway and Park Commission Building and adjacent golf course. Wastewater generated in the area would be conveyed to the Racine sewer service area for treatment at the City of Racine treatment plant.

*Source: SEWRPC.*

Under Alternative Plan 2, all wastewater from the Yorkville sewer service area would be conveyed to the Sturtevant sanitary sewer system, then to the Racine wastewater treatment plant. This facility would discharge its effluent directly to Lake Michigan as described under the Kenosha-Racine subregional area alternative analysis. As previously noted, the areawide water quality management plan proposes that the Racine wastewater treatment plant provide secondary waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Yorkville sewer service area is about $750,400. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $958,500, with an estimated average annual operation and maintenance cost of $10,800 (see Table 138).

Since, on an equivalent annual basis, the costs of implementing Alternative Plan 1 and Alternative Plan 2 are almost equal, plan selection must be based upon other less tangible, but nevertheless real, considerations. The first alternative has certain advantages concerning ease of implementation in that a wastewater treatment facility would continue to be operated by the present operating agencies. The second alternative has the advantage of eliminating one wastewater treatment facility, thus avoiding the duplication of staff and related facilities and the added monitoring associated with two plants. Alternative Plan 2 also has an advantage in that the level of treatment required is less than that required under Alternative Plan 1, and thereby less manpower and energy is required. However, the potential future requirement for increased levels of treatment prior to discharge into Lake Michigan is a real consideration. As noted under the discussions on the Milwaukee metropolitan and Kenosha-Racine subregional areas, higher levels of

Table 138

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE YORKVILLE SEWER SERVICE AREA: ROOT RIVER CANAL SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Town of Yorkville | | | | | | | | |
| Facilities. . . . . . . . . . | $685,500 | $15,400 | $527,600 | $220,500 | $748,100 | $33,500 | $14,000 | $47,500 |
| Land . . . . . . . . . . . . | 49,500 | - - | 28,400 | - - | 28,400 | 1,800 | - - | 1,800 |
| Subtotal | $735,000 | $15,400 | $556,000 | $220,500 | $776,500 | $35,300 | $14,000 | $49,300 |
| Trunk Sewers—None . . . . . | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $735,000 | $15,400 | $556,000 | $220,500 | $776,500 | $35,300 | $14,000 | $49,300 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Racine[a] . . . . . . . | $ 18,600 | $ 5,200 | $ 9,900 | $ 81,800 | $ 91,700 | $ 600 | $ 5,200 | $ 5,800 |
| Trunk Sewers | | | | | | | | |
| Yorkville to Sturtevant. . . | 752,900 | 5,400 | 482,100 | 75,400 | 557,500 | 30,600 | 4,800 | 35,400 |
| Sturtevant to Racine . . . . | 187,000 | 200 | 98,300 | 2,900 | 101,200 | 6,200 | 200 | 6,400 |
| Subtotal | $939,900 | $ 5,600 | $580,400 | $ 78,300 | $658,700 | $36,800 | $ 5,000 | $41,800 |
| Total | $958,500 | $10,800 | $590,300 | $160,100 | $750,400 | $37,400 | $10,200 | $47,600 |

[a] *Costs are based upon a portion of the City of Racine wastewater treatment facility cost based upon the proportion of flow tributary to the City of Racine from the Yorkville sewer service area.*

*Source: SEWRPC.*

treatment may be required for the treatment plants serving the Milwaukee metropolitan area and the Cities of Kenosha, Racine, and South Milwaukee as a result of agreements or settlements with the State of Illinois. Conversely, Alternative Plan 1 provides for elimination of all wastewater discharges from the Yorkville sewer service area, provided the effluent land application system is satisfactorily implemented. Alternative Plan 2 also has a disadvantage in that it requires the construction of a system to convey wastewater from the Yorkville area to the Sturtevant sewer system. Thus, Alternative Plan 2 would have a greater impact on the environment and affect a greater population than would Alternative Plan 1. Based upon all these considerations, neither alternative is clearly better. However, based principally upon the ease of implementation, Alternative Plan 1—expansion and upgrading of the existing facility in the Yorkville sewer service area—is recommended.

Private Wastewater Treatment Plants

There are seven private wastewater treatment facilities in the Root River Canal subregional area which serve isolated enclaves of urban land uses and generally treat wastes which can be accepted in public sanitary sewerage systems. These facilities currently discharge treated wastewaters to the streams and groundwaters in the Root River Canal subregional area. These facilities serve C&D Foods, York Duck Farms, Pekin Duck Farm, the Racine County Highway and Park Commission, and Fonk's Mobile Home Park No. 1 in in the Town of Yorkville; Grove Duck Farm in the Town of Raymond; and Meeter Brothers Company and the Center for the Developmentally Disabled in the Town of Dover.

Except for the facilities serving the Center for the Developmentally Disabled and the Racine County Highway and Park Commission Building, which are described above, and Meeter Brothers Company, each of these facilities lies beyond the proposed year 2000 service area of the public sanitary sewerage systems in the subregional area. These facilities, accordingly, must be retained and, as necessary, upgraded to provide a level of waste treatment adequate to meet the water use objectives and standards for the streams within the Root River Canal subregional area. The private plant serving the Center for the Developmentally Disabled would be abandoned, and that area would be interconnected to the Union Grove sewer service area for wastewater treatment. The facility serving the Racine County Highway and Park Commission Building is discussed in the previous section, and is proposed to be expanded and upgraded, and reclassified as a public wastewater treatment plant. The Meeter Brothers Company facility lies within the proposed year 2000 sewer service area limits of the Union Grove sewer service area. However, the facility is a specialized treatment system constructed for the purpose of treating canning wastes with relatively high and seasonally variable waste strength and volume. This facility is proposed to be retained, and should be upgraded as necessary to meet the recommended water use objectives and supporting standards for the streams in the area of this facility.

Based upon the general analysis described earlier in this chapter, land application of plant effluent is considered to be less costly than providing advanced waste treatment prior to discharge to the surface water for facilities the size of the four private plants noted above to be retained. The proposed plan for these plants is based upon the provision of land application of plant effluent (see Table 139).

Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to the surface waters should be considered.

The estimated present worth for construction and operation of the necessary private wastewater treatment facilities in the Root River Canal subregional area over a 50-year analysis period is about $2,705,000. The estimated capital cost for constructing the necessary facilities is about $1,890,000, with an estimated average operation and maintenance cost of $81,000.

### Existing Unsewered Urban Development Outside the Proposed Sanitary Sewer Service Area

There are three enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area, as shown on Map 56. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are listed in Table 140. In a generalized alternative analysis described earlier in this chapter, the cost of providing public sewerage service to these enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that analysis, it was concluded that wastewater treatment for these enclaves of unsewered urban development should be provided in one of two ways.

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan proposal is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. One of the unsewered urban areas was included in this category—the Town of Raymond—Section 13 in Racine County.

Table 139

WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE ROOT RIVER CANAL SUBREGIONAL AREA

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| C&D Foods-York Duck Farm | Town of Yorkville | Industrial | Process and Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Fonk's Mobile Home Park No. 1 | Town of Yorkville | Residential | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Grove Duck Farm | Town of Raymond | Industrial | Process and Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Meeter Brothers Company | Town of Dover | Industrial | Process and Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Pekin Duck Farm | Town of Yorkville | Industrial | Process | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

*Source: SEWRPC.*

Table 140

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE ROOT RIVER CANAL SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population 1975 | Estimated Resident Population 2000 | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | Racine County | | | |
| 1 | Town of Raymond–Section 6 | 137 | 212 | 3.5 |
| 2 | Town of Raymond–Section 13 | 170 | 162 | 2.1 |
| 3 | Town of Yorkville–Sections 26 and 27 | 484 | 506 | 2.1 |
| Total | | 791 | 880 | - - |

[a] *See Map 56.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

For the remaining enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. The two urban enclaves which should consider alternative methods of onsite waste disposal, as well as an intensive inspection and maintenance program for conventional systems, are the Town of Raymond—Section 6 and the Town of Yorkville—Sections 26 and 27 in Racine County. These areas generally have soil conditions and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

Sanitary Sewer System Flow Relief Devices

In 1975 there was one sanitary sewer system flow relief device in the Root River Canal subregional area. The proposed plan recommends that local planning efforts include the formulation of a plan for the elimination of this sewage flow relief device.

Other Known Point Sources of Wastewater

There are a total of six known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Root River Canal subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of five-day biochemical oxygen demand ($BOD_5$), ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar surface water bodies. Thus, in most cases no further treatment recommendations were advanced for these other point sources with regard to these constituents. However, it is recommended that the remaining point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 141.

There are no costs calculated for these point sources in the Root River Canal subregional area. From the limited data available on these point sources, no additional treatment appears to be required. Only one point source in this category was noted as needing further treatment consideration. That facility had a relatively low flow and effluent concentrations were bordering acceptable levels. Thus, the cost of treatment or substitution of process changes was estimated to be minimal.

DES PLAINES RIVER SUBREGIONAL AREA

The Des Plaines River subregional area consists of all that part of the Des Plaines River watershed in Kenosha and Racine Counties except for the concentration of urban development along the shorelines of Lake Shangrila and Benet Lake in the Towns of Bristol and Salem, which has been grouped with adjacent development on the shorelines of Voltz Lake and Cross Lake in the Lower Fox River subregional area for sewerage system planning purposes, and a portion of the urban area of the Village of Union Grove, placed in the Root River Canal subregional area for planning purposes. The Des Plaines River subregional area consists of predominantly rural and agricultural land uses, with relatively small concentrations of urban development in the Towns of Pleasant Prairie, Bristol, and Salem and the Village of Paddock Lake.

Table 141

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION— ROOT RIVER CANAL SUBREGIONAL AREA: 1975

| Point Source Discharge: Name | Point Source Discharge: Civil Division Location | Average Flow 1975 (mgd) | Receiving Water Body | Constituents[a] Requiring Treatment Consideration |
|---|---|---|---|---|
| Culligan Water Conditioning Company . . | Village of Union Grove | 0.001 | Des Plaines River via Storm Sewer | Suspended Solids |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System, reports filed under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Centralized sanitary sewer service in the Des Plaines River subregional area was provided by five systems in 1975: those operated by the Village of Paddock Lake; the Town of Pleasant Prairie Sewer Utility District D; the Town of Pleasant Prairie Sanitary District No. 73-1; the Town of Bristol Sewer Utility District No. 1, and the Town of Salem Sewer Utility District No. 1. Together, the service areas of these five systems comprised about 2.7 square miles and served an estimated population of 4,800 persons. In 1975 there were about 7,200 persons residing within the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the five existing systems are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Sewer Service Analysis Areas

A total of six sewer service analysis areas have been identified within the Des Plaines River subregional area (see Table 142). These six sewer service analysis areas are shown on Map 61 and may be described as follows:

1. Area A—This area consists of the Village of Paddock Lake and environs. In 1975 sanitary sewer service was provided in this area to about 0.8 square mile, having a total resident population of about 1,900 persons. The total area anticipated to be served by the year 2000 approximates 1.7 square miles, with a projected resident population of about 3,300 persons. This represents a decrease in planned population from the 3,800 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Paddock Lake" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Town of Salem Sewer Utility District No. 1 and environs, including existing and proposed urban development along the shorelines of Hooker and Montgomery Lakes. In 1975 sanitary sewer service was provided in this area to about 0.4 square mile, having a total resident population of about 1,000 persons. The total area anticipated to be served by the year 2000 approximates 1.4 square miles, with a projected resident population of about 1,800 persons. This represents an increase in the planned population from the 1,300 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Hooker-Montgomery Lakes" sewer service area in the ensuing discussion.

3. Area C—This area consists of the Town of Bristol Sewer Utility District No. 1 and environs, including existing and proposed urban development in the unincorporated village of Bristol and along the shoreline of George Lake. In 1975 sanitary sewer service was provided in this area to about 0.7 square mile, having a total resident population of about 800 persons. The total area anticipated to be served by the year 2000 approximates 1.7 square miles, with a projected resident population of about 2,000 persons. This represents an increase in the planned population from the 1,500 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Bristol-George Lake" sewer service area in the ensuing discussion.

**Table 142**

**SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE DES PLAINES RIVER SUBREGIONAL AREA: 1975, 1985, AND 2000**

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Resident Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Resident Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Resident Population Served | Design Hydraulic Loading (mgd) |
| A | Paddock Lake | 0.79 | 1,900 | 0.17 | - - | 2,800 | 0.36 | 1.72 | 3,300 | 0.46 |
| B | Hooker-Montgomery Lakes | 0.37 | 1,000 | 0.08 | 200 | 1,400 | 0.16 | 1.35 | 1,800 | 0.25 |
| C | Bristol-George Lake | 0.72 | 800 | 0.07 | - - | 1,400 | 0.20 | 1.73 | 2,000 | 0.32 |
| D | Bristol-IH 94 | - - | - - | - - | 100 | 100 | 0.29[b] | 0.51 | 300 | 0.33[b] |
| E | Pleasant Prairie-North | 0.68 | 1,000 | 0.10 | 100 | 2,000 | 0.31 | 2.52 | 3,000 | 0.52 |
| F | Pleasant Prairie-South | 0.09 | 100 | 0.03 | 600 | 700 | 0.16[c] | 3.24 | 1,000 | 0.22[c] |
| | Total | 2.65 | 4,800 | 0.45 | 1,200 | 8,400 | 1.48 | 11.07 | 11,400 | 2.10 |

[a] *See Map 61.*

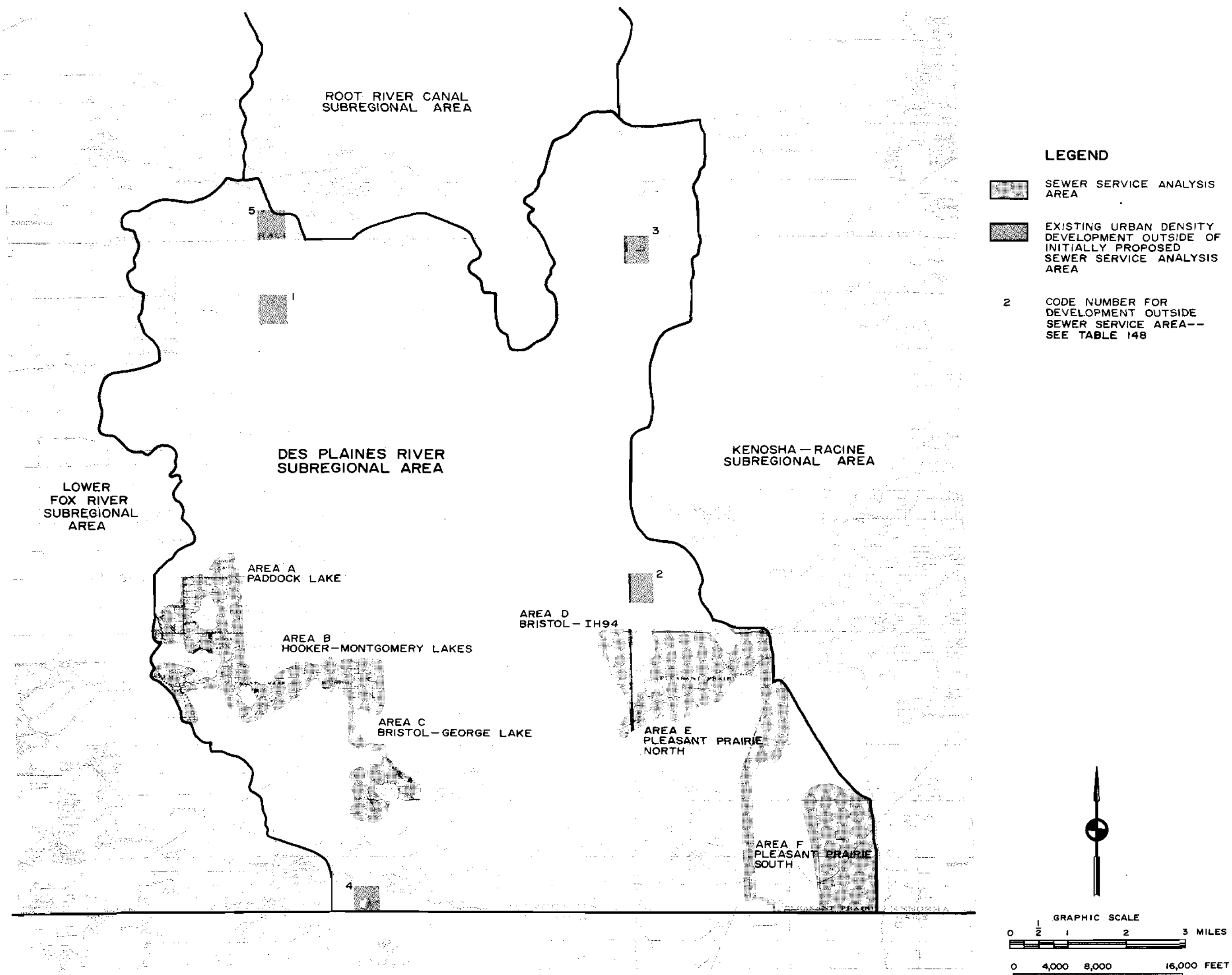
[b] *Includes a projected industrial-commercial loading of 0.27 mgd.*

[c] *Includes an estimated loading of 10,000 gallons per day from the Wisconsin Electric Power Company generating facility under construction in 1978 in the Town of Pleasant Prairie.*

*Source: SEWRPC.*

Map 61

SEWER SERVICE ANALYSIS AREAS: DES PLAINES RIVER SUBREGIONAL AREA




Six individual sewer service analysis areas were identified within the Des Plaines River subregional area. These include the Village of Paddock Lake, the Hooker-Montgomery Lakes area in the Town of Salem, the unincorporated village of Bristol and Lake George area in the Town of Bristol, the commercial-industrial land use complex located along IH 94 in the Town of Bristol, the unincorporated village of Pleasant Prairie, and a complex of existing and proposed urban land use concentrations in the Town of Pleasant Prairie near the Illinois-Wisconsin State line and west of the subcontinental divide. By the year 2000, about 11,400 persons are expected to reside in these six sewer service areas, which will approximate 11.07 square miles. In 1975 there were about 12,000 persons residing in the Des Plaines River subregional area, of which 4,800 persons were served by centralized sewer service and 7,200 by onsite sewage disposal systems.

*Source: SEWRPC.*

4. Area D—This area consists of a portion of the Town of Bristol lying along IH 94 between the STH 50 and CTH C interchanges. While no public sanitary sewer service was provided in this area in 1975, one private sewage treatment facility was operated in the area serving the Howard Johnson Motor Lodge and an adjacent automobile service station. In addition, wastes from the truck service center operated by Beaver Transport Company and Quality Carriers, Inc., are currently trucked to the City of Kenosha wastewater treatment plant, while the McDonald's restaurant, which began operation in the area late in 1977, is served by a holding tank. The Town of Bristol has proposed the establishment of a public sanitary sewerage system to serve this area. The total area anticipated to be served by the year 2000 approximates 0.5 square mile, with a projected

resident population of 300 people. An estimated industrial-commercial wastewater loading equivalent of 1,300 people is included in the forecast hydraulic loading for this area. This represents the same equivalent population of 1,600 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Bristol-IH 94" sewer service area in the ensuing discussion.

5. Area E—This area consists of the Town of Pleasant Prairie Sewer Utility District D. In 1975 sanitary sewer service was provided in this area to about 0.7 square mile, having a total resident population of about 1,000 persons. The total area anticipated to be served by the year 2000 approximates 2.5 square miles, with a projected resident population of about 3,000 persons. This represents an increase in the planned population from the 800 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Pleasant Prairie-North" sewer service area in the ensuing discussion.

6. Area F—This area consists of a portion of the Town of Pleasant Prairie Sanitary District No. 73-1, including the site of the proposed Wisconsin Electric Power Company power generation plant now under construction north of CTH T in Section 16 of the Town of Pleasant Prairie. In 1975 sanitary sewer service was provided in this area to about 0.1 square mile, having a total resident population of about 100 persons. The total area anticipated to be served by the year 2000 approximates 3.2 square miles, with a projected resident population of about 1,000 persons. This represents a decrease from the 2,800 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. However, under that plan, 2,000 persons of the forecast population were anticipated due to local development plans which were current at the time and which were not allocated to the area under the adopted 1990 regional land use plan. As of 1975, these plans had not been put in effect. This subarea is referenced as the "Pleasant Prairie-South" sewer service area in the ensuing discussion.

## Formulation of Alternatives

As noted earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system plan for the formulation and evaluation of alternative public sanitary sewerage system plans. First, the potential for interconnection of community sanitary sewerage systems was evaluated. Two interconnections in the Des Plaines River subregional area—Hooker-Montgomery Lakes to Paddock Lake and Bristol IH 94 to Pleasant Prairie-North—were found to be potentially feasible through the application of Wisconsin Department of Natural Resources guidelines concerning distances between and population of communities. Preliminary economic analyses were then made for those interconnections which were found to be potentially feasible, with a more detailed analysis conducted for those systems which continued to appear feasible following the preliminary analyses. A detailed economic analysis was made for two alternative plans for the Paddock Lake and Hooker-Montgomery Lakes sewer service areas. One alternative provided for a joint treatment facility to serve both areas, while the second alternative, which was ultimately recommended, provided for separate treatment of the wastewater from each service area. A detailed discussion of these alternative proposals can be found in Chapter XI of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.

Because the water quality simulation work performed under the areawide water quality management planning program indicated that somewhat higher levels of wastewater treatment were required for the point sources in the Des Plaines River subregional area than had been recommended in the regional sanitary sewerage system plan, the two interconnections which were found to be potentially feasible in the earlier study were reconsidered, and new economic analyses were conducted. In addition, because the interconnection of the Paddock Lake and Hooker-Montgomery Lakes sewer service areas was deemed to be a viable alternative following the economic analyses, an additional alternative was evaluated which would combine the Bristol-George Lake sewer service area with the Paddock Lake and Hooker-Montgomery Lakes service areas. An alternative plan was also analyzed which would provide for a single treatment facility—located at the site of the existing plant operated by the Town of Pleasant Prairie Sanitary District No. 73-1—to serve all of the urban development in the Town of Pleasant Prairie west of the subcontinental divide, as well as the highway-oriented commercial development located along IH 94 in the Town of Bristol. Accordingly, it was determined that the following sanitary sewerage system plans for the Des Plaines River subregional area should be prepared:

1. Three alternative plans on the number and location of treatment facilities needed to serve the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service areas.

2. Three alternative plans on the number and location of treatment facilities needed to serve the Paddock Lake, Hooker-Montgomery Lakes, and Bristol-George Lake sewer service areas.

Results of water quality simulations are presented under the previous section on the diffuse source control element recommendations for the Des Plaines River watershed.

Based upon the results of the water quality simulation work conducted under the areawide water quality management program, it was concluded that in order to meet established water quality objectives, it would be necessary to provide a high level of advanced waste treatment for phosphorus removal in the Des Plaines River subregional area in addition to the levels of waste treatment recommended under the regional sanitary sewerage system plan. The effect of these recommended performance standards on the public wastewater treatment plants is noted in the following sections. Sanitary sewerage system plans for the six sewer service areas that lie within the Des Plaines River subregional area are described in the following sections.

Alternative Plans—Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South Subareas

As noted above, alternative analyses were conducted which considered the interconnection of the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South subareas for wastewater treatment plant purposes. Three basic alternative plans were formulated. The first alternative plan assumes the provision of three individual wastewater treatment plants to serve the three sewer service areas. The second alternative plan would provide for the consolidation of the Bristol-IH 94 and Pleasant Prairie-North treatment facilities at the site of the existing Pleasant Prairie-North treatment plant, together with upgrading of the Pleasant Prairie-South treatment facility. The third alternative plan would provide for a single centralized sewage treatment plant at the site of the existing Pleasant Prairie-South treatment facility. The recommended sewage treatment levels and performance standards under the three alternatives are set forth in Table 143, and the three proposals are shown on Maps 62, 63, and 64.

In order to meet established water use objectives for the Des Plaines River, the treatment plants proposed under each of the three alternative plans will need to provide either a secondary level of wastewater treatment followed by auxiliary waste treatment for effluent disinfection and land application of the treatment plant effluent, or secondary waste treatment with advanced and auxiliary waste treatment, including a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus. The recommendations regarding treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan. That plan recommended separate treatment facilities to serve each of the subareas in the watershed, and the provision of secondary waste treatment plus conventional advanced waste treatment for phosphorus removal—with an effluent concentration of 1.0 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection for the Pleasant Prairie Sanitary District No. 73-1 facility; secondary waste treatment plus auxiliary waste treatment for effluent disinfection for the Pleasant Prairie Sewer Utility District D facility; and secondary waste treatment plus auxiliary waste treatment for effluent aeration and disinfection for the new Bristol-IH 94 facility.

Based upon the general analyses described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application is considered to be less costly than providing secondary waste treatment followed by a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment. The simulation model studies indicated that the water quality standards for phosphorus cannot be achieved for the Des Plaines River when conventional advanced waste treatment for phosphorus removal is provided prior to discharge of the plant effluent to the surface waters. The phosphorus standard can be achieved about 90 percent of the time if land application of effluent is practiced, or if a high level of advanced waste treatment for phosphorus removal is provided prior to discharge to the surface waters and if the appropriate level of nonpoint source pollution control is achieved. Accordingly, the effluent land application alternative is recommended. Should local facility planning efforts indicate that land application of plan effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with the effluent discharged to the surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practicable level, and to ultimately reduce the total phosphorus concentration in the plant effluent to about 0.1 mg/l.

Under Alternative Plan 1, a new wastewater treatment plant would be constructed to serve the existing and proposed commercial, industrial, and residential development located along IH 94 between the STH 50 and CTH C interchanges. The Town of Bristol had proposed the establishment of a public sanitary sewerage system to serve this area. The Town had estimated a total design hydraulic loading from the area of 0.33 mgd. This hydraulic design flow, which has been utilized as the year 2000 hydraulic loading, is the same as the estimated 1990 design capacity utilized in the regional sanitary sewerage system plan. The establishment of a sanitary sewerage system in this area would resolve existing wastewater treatment problems that now necessitate the trucking of industrial wastes to the City of Kenosha wastewater treatment facility, and would permit the abandonment of the existing private wastewater treatment facility serving the Howard Johnson Motor Lodge, and of the holding tanks now serving other commercial facilities in the area.

In addition to the new plant to serve the Bristol-IH 94 area, the existing treatment plants serving the Pleasant Prairie-North and Pleasant Prairie-South areas would be upgraded. In 1975 the wastewater treatment facility serving the Town of Pleasant Prairie Sewer Utility District D had an average hydraulic design capacity of about 0.13 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Pleasant Prairie-North sewer service area of about 0.31 mgd in 1985 and about 0.52 mgd in the year 2000. This year 2000 design flow is considerably larger than the estimated 1990 design flow of 0.09 mgd anticipated under the regional sanitary sewerage system plan.

Table 143

## WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BRISTOL-IH 94, PLEASANT PRAIRIE-NORTH, AND PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREAS: DES PLAINES RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| Bristol-IH 94 Proposed District | 0.29[b] | 0.33[b] | Bristol-IH 94 | 100 | 300 | Secondary<br>Auxiliary<br><br>Advanced[c] | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Town of Pleasant Prairie Sewer Utility District D | 0.31 | 0.52 | Pleasant Prairie-North | 2,000 | 3,000 | Secondary<br>Auxiliary<br><br>Advanced[d] | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Town of Pleasant Prairie Sanitary District No. 73-1 | 0.16[e] | 0.22[e] | Pleasant Prairie-South | 700 | 1,000 | Secondary<br>Auxiliary<br><br>Advanced[f] | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Alternative Plan 2[g] | | | | | | | | |
| Town of Pleasant Prairie Sewer Utility District D | 0.60[b] | 0.85[b] | Pleasant Prairie-North<br>Bristol-IH 94 | 2,100 | 3,300 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Town of Pleasant Prairie Sanitary District No. 73-1 | 0.16[e] | 0.22[e] | Pleasant Prairie-South | 700 | 1,000 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Alternative Plan 3[g] | | | | | | | | |
| Town of Pleasant Prairie Sanitary District No. 73-1 | 0.76[b,e] | 1.07[b,e] | Pleasant Prairie-South<br>Bristol-IH 94<br>Pleasant Prairie-North | 2,800 | 4,300 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] *See Map 61.*

[b] *Includes a projected industrial-commercial loading of 0.27 mgd.*

[c] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent aeration and disinfection prior to discharge of effluent to the surface waters.*

[d] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection prior to discharge of effluent to the surface waters.*

[e] *Includes an estimated loading of 10,000 gallons per day from the Wisconsin Electric Power Company generating facility under construction in the Town of Pleasant Prairie (1978).*

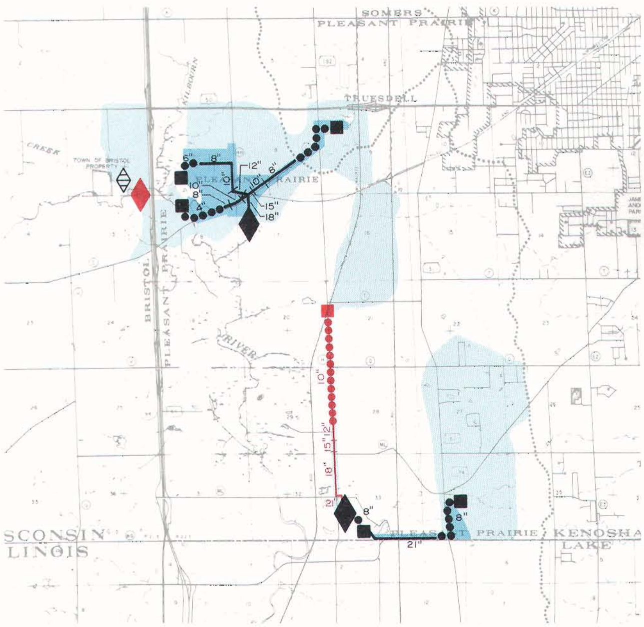
[f] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations which included the provision of secondary waste treatment with conventional advanced waste treatment for phosphorus removal (effluent concentration of 1.0 mg/l) and effluent aeration and disinfection prior to discharge of effluent to the surface waters.*

[g] *Recommended wastewater treatment levels were not specifically reported in the regional sanitary sewerage system plan for this alternative.*

*Source: SEWRPC.*

Map 62

## ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1 FOR THE BRISTOL-IH 94, PLEASANT PRAIRIE-NORTH, AND PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREAS— DES PLAINES RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREA
- EXISTING 1975
- PROPOSED 2000

SEWAGE TREATMENT FACILITIES
- EXISTING PUBLIC TO BE RETAINED
- PROPOSED PUBLIC
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES
- EXISTING TRUNK SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION

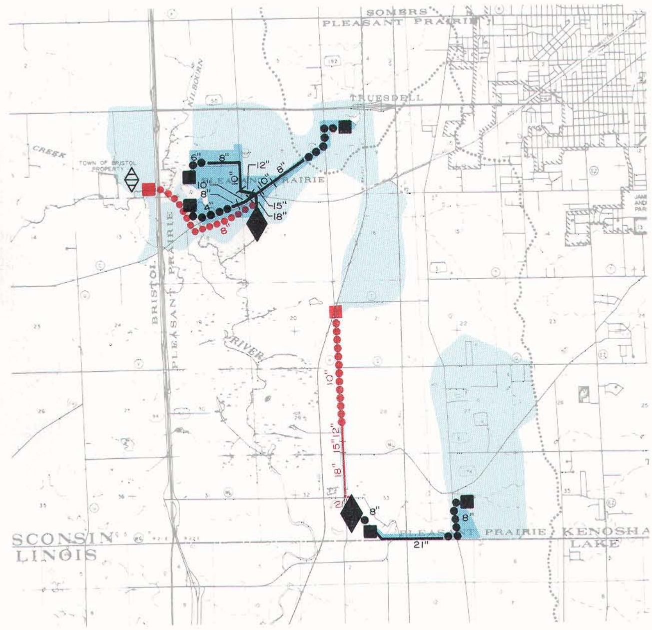
GRAPHIC SCALE
0 ½ 1 2 MILES
0 4000 8000 12000 FEET

The first alternative plan considered for the Bristol-IH 94, Pleasant Prairie-North and Pleasant Prairie-South sewer service areas proposes the upgrading and continued operation of wastewater treatment facilities in the Pleasant Prairie-North and Pleasant Prairie-South sewer service areas, and establishment of a new facility to serve the Bristol-IH 94 sewer service area. This plan further proposes that all three of these plants provide secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application of effluent or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Des Plaines River.

*Source: SEWRPC.*

Map 63

## ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2 FOR THE BRISTOL-IH 94, PLEASANT PRAIRIE-NORTH, AND PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREAS— DES PLAINES RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREA
- EXISTING 1975
- PROPOSED 2000

SEWAGE TREATMENT FACILITIES
- EXISTING PUBLIC TO BE RETAINED
- EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES
- EXISTING TRUNK SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION

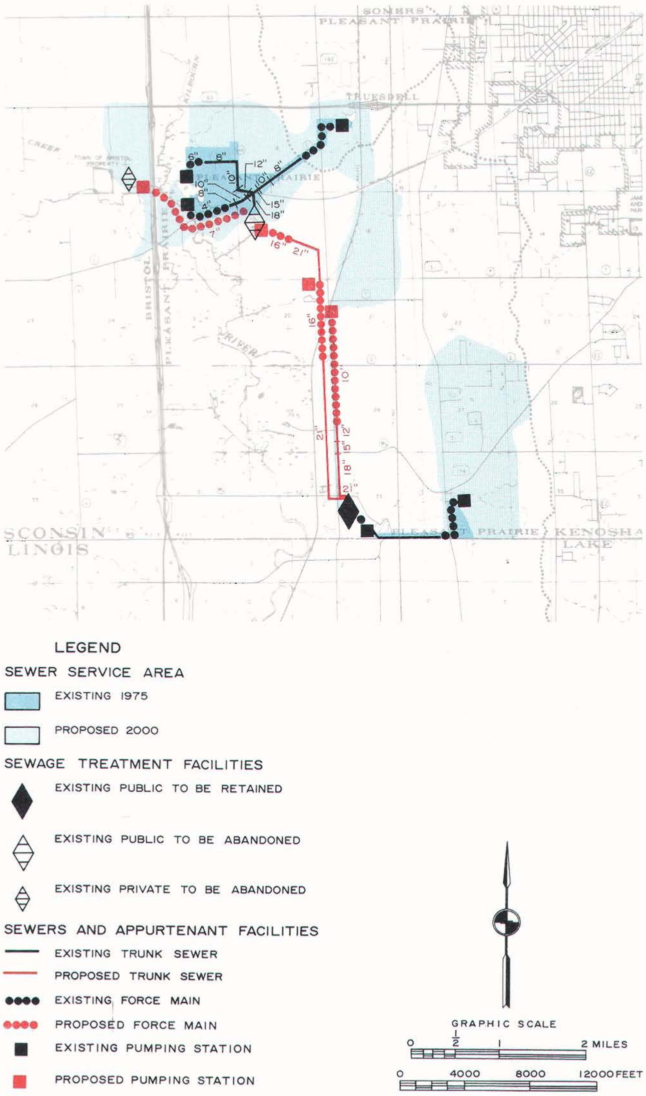
GRAPHIC SCALE
0 ½ 1 2 MILES
0 4000 8000 12000 FEET

The second alternative plan considered for the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service area proposes connections of the Bristol-IH 94 sewer service area to an upgraded and expanded Pleasant Prairie-North treatment facility. The treatment facility presently serving the Pleasant Prairie-South sewer service area would also be upgraded. Both of the proposed treatment plants would provide secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application of effluent, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Des Plaines River.

*Source: SEWRPC.*

Map 64

**ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 3 FOR THE BRISTOL-IH 94, PLEASANT PRAIRIE-NORTH, AND PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREAS— DES PLAINES RIVER SUBREGIONAL AREA: 2000**




The third alternative plan considered for the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service areas proposes the consolidation of all sewage treatment at the existing Pleasant Prairie-South treatment site. Under this alternative, the Pleasant Prairie-South facility would be expanded and upgraded to provide secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application of effluent, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Des Plaines River.

*Source: SEWRPC.*

In 1975 the wastewater treatment facility serving the Town of Pleasant Prairie Sanitary District No. 73-1 had an average hydraulic design capacity of about 0.40 mgd and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Pleasant Prairie-South sewer service area of about 0.16 mgd in 1985 and about 0.22 mgd in the year 2000, which is below the existing design capacity. This year 2000 design flow is lower than the estimated design flow of 0.60 mgd anticipated under the regional sanitary sewerage system plan. The 1990 design flow was based upon a projected population of 2,800 persons, which included 2,000 persons estimated to be tributary to the proposed facility in local development plans which were not included in the 1990 regional land use plan allocations of population. As of 1975, these plans had not been put in effect. Under the newly adopted year 2000 regional land use plan, therefore, the total population which was allocated to the Pleasant Prairie-South subarea was about 1,000 persons.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities included under Alternative Plan 1 for the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service areas is about $6,908,000. The estimated capital cost for constructing the necessary additional treatment facilities is $5,881,000, with an estimated average annual operation and maintenance cost of $197,000 (see Table 144).

Alternative Plan 2 for the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service area is similar to Alternative Plan 1, except that no new facility would be constructed at the Bristol-IH 94 area and that sewer service would be connected by a trunk sewer to an expanded Pleasant Prairie-North sewage treatment facility. Under this alternative, the Pleasant Prairie-North treatment facility would be expanded to provide an average hydraulic capacity of 0.85 mgd.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service areas is about $6,025,000. The estimated capital cost for constructing the necessary additional facilities is $4,947,000, with an estimated average annual operation and maintenance cost of $162,000 (see Table 144).

The third alternative plan considered for the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service areas would consolidate all sewage treatment at the existing Pleasant Prairie-South treatment plant site. Under this alternative, the Pleasant Prairie-South treatment plant would provide an average hydraulic plant capacity of about 1.07 mgd. Trunk sewers to serve the Bristol-IH 94 and Pleasant Prairie-North sewer service areas would be constructed to convey wastewater from these areas to the Pleasant Prairie-South plant site.

## Table 144

## DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERANTIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BRISTOL-IH 94, PLEASANT PRAIRIE-NORTH, AND PLEASANT PRAIRIE-SOUTH SEWER SERVICE AREAS: DES PLAINES RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Town of Pleasant Prairie | | | | | | | | |
| Sewer Utility District D | | | | | | | | |
| Facilities. . . . . . . . . . . | $2,281,000 | $ 73,000 | $1,687,000 | $ 947,000 | $2,634,000 | $107,000 | $ 60,000 | $167,000 |
| Land . . . . . . . . . . . . . | 185,000 | - - | 106,000 | - - | 106,000 | 7,000 | - - | 7,000 |
| Subtotal | $2,466,000 | $ 73,000 | $1,793,000 | $ 947,000 | $2,740,000 | $114,000 | $ 60,000 | $174,000 |
| Bristol-IH 94 | | | | | | | | |
| Facilities. . . . . . . . . . . | 1,845,000 | 68,000 | 1,364,000 | 968,000 | 2,332,000 | 86,000 | 61,000 | 147,000 |
| Land . . . . . . . . . . . . . | 134,000 | - - | 77,000 | - - | 77,000 | 5,000 | - - | 5,000 |
| Subtotal | $1,979,000 | $ 68,000 | $1,441,000 | $ 968,000 | $2,409,000 | $ 91,000 | 61,000 | $152,000 |
| Town of Pleasant Prairie | | | | | | | | |
| Sanitary District No. 73-1 | | | | | | | | |
| Facilities. . . . . . . . . . . | $1,337,000 | $ 56,000 | $ 858,000 | $ 844,000 | $1,702,000 | $ 54,000 | $ 54,000 | $108,000 |
| Land . . . . . . . . . . . . . | 99,000 | - - | 57,000 | - - | 57,000 | 4,000 | - - | 4,000 |
| Subtotal | $1,436,000 | $ 56,000 | $ 915,000 | $ 844,000 | $1,759,000 | $ 58,000 | $ 54,000 | $112,000 |
| Total | $5,881,000 | $197,000 | $4,149,000 | $2,759,000 | $6,908,000 | $263,000 | $175,000 | $438,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Combined Facility, | | | | | | | | |
| Bristol-IH 94 and | | | | | | | | |
| Pleasant Prairie Sewer | | | | | | | | |
| Utility District D | | | | | | | | |
| Facilities. . . . . . . . . . . | $2,883,000 | $100,000 | $2,233,000 | $1,503,000 | $3,736,000 | $142,000 | $ 95,000 | $237,000 |
| Land . . . . . . . . . . . . . | 288,000 | - - | 165,000 | - - | 165,000 | 10,000 | - - | 10,000 |
| Subtotal | $3,171,000 | $100,000 | $2,398,000 | $1,503,000 | $3,901,000 | $152,000 | $ 95,000 | $247,000 |
| Pleasant Prairie Sanitary | | | | | | | | |
| District No. 73-1 | | | | | | | | |
| Facilities. . . . . . . . . . . | $ 905,000 | $ 56,000 | $ 702,000 | $ 836,000 | $1,538,000 | $ 44,000 | $ 53,000 | $ 97,000 |
| Land . . . . . . . . . . . . . | 99,000 | - - | 57,000 | - - | 57,000 | 4,000 | - - | 4,000 |
| Subtotal | $1,004,000 | $ 56,000 | $ 759,000 | $ 836,000 | $1,595,000 | $ 48,000 | $ 53,000 | $101,000 |
| Subtotal— Treatment Plants | $4,175,000 | $156,000 | $3,157,000 | $2,339,000 | $5,496,000 | $200,000 | $148,000 | $348,000 |
| Trunk Sewer | | | | | | | | |
| Bristol-Pleasant Prairie . . . . | $ 772,000 | $ 6,000 | $ 453,000 | $ 76,000 | $ 529,000 | $ 29,000 | $ 5,000 | $ 34,000 |
| Total | $4,947,000 | $162,000 | $3,610,000 | $2,415,000 | $6,025,000 | $229,000 | $153,000 | $382,000 |
| Alternative Plan 3 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Combined Facility, | | | | | | | | |
| Bristol-IH 94 | | | | | | | | |
| Pleasant Prairie Sewer | | | | | | | | |
| Utility District D and | | | | | | | | |
| Pleasant Prairie Sanitary | | | | | | | | |
| District No. 73-1 | | | | | | | | |
| at South Location | | | | | | | | |
| Facilities . . . . . . . . . . | $3,374,000 | $104,000 | $2,499,000 | $1,711,000 | $4,210,000 | $159,000 | $108,000 | $267,000 |
| Land. . . . . . . . . . . . . | 347,000 | - - | 199,000 | - - | 199,000 | 12,000 | - - | 12,000 |
| Subtotal | $3,721,000 | $104,000 | $2,698,000 | $1,711,000 | $4,409,000 | $171,000 | $108,000 | $279,000 |
| Trunk Sewers | | | | | | | | |
| Bristol-Pleasant Prairie . . . . | $ 772,000 | $ 6,000 | $ 453,000 | $ 76,000 | $ 529,000 | $ 29,000 | $ 5,000 | $ 34,000 |
| Pleasant Prairie-North . . . . | $1,883,000 | 7,000 | 916,000 | 73,000 | 989,000 | 58,000 | 5,000 | 63,000 |
| Subtotal | $2,655,000 | $ 13,000 | $1,369,000 | $ 149,000 | $1,518,000 | $ 87,000 | $ 10,000 | $ 97,000 |
| Total | $6,376,000 | $117,000 | $4,067,000 | $1,860,000 | $5,927,000 | $258,000 | $118,000 | $376,000 |

*Source: SEWRPC.*

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 3 for the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service areas is about $5,927,000. The estimated capital cost for constructing the necessary additional facilities is $6,376,000, with an estimated average annual operation and maintenance cost of $117,000 (see Table 144).

On an equivalent annual basis, Alternative Plan 2 would be about 13 percent less costly to implement than would Alternative Plan 1 and would cost about the same as Alternative Plan 3. Because the costs of Alternative Plans 2 and 3 are virtually identical, plan selection must be based upon other less tangible, but nevertheless real, considerations. The third alternative has the advantage of providing only one treatment facility to serve all of the urban development in the Town of Pleasant Prairie west of the subcontinental divide, as well as the highway-oriented commercial development along IH 94, thus avoiding the duplication of staff and related facilities associated with two plants. The monitoring requirements associated with the treatment facilities would also be less under Alternative Plan 3. In addition, the third alternative has the advantage of fully utilizing the existing capacity of the Town of Pleasant Prairie Sanitary District No. 73-1 treatment facility, which was constructed in 1975 with a capacity of 0.40 mgd—a capacity greater than the design capacity required under Alternative Plan 2. However, the total construction requirement for conveyance and treatment of wastewater is less under Alternative Plan 2.

The third alternative has an inherent disadvantage in that it requires the conveyance of wastewater from the Pleasant Prairie-North sewer service area to the Pleasant Prairie-South sewer service area. Thus, Alternative Plan 3 would have a greater impact on the environment and affect a greater population than would Alternative Plan 2. In addition, under Alternative Plan 3 additional pumping, with its associated energy use, would be required to convey the wastes from the Pleasant Prairie-North sewer service area to the Pleasant Prairie-South sewer system.

The second alternative has certain advantages concerning the probability of implementation in that sewage treatment facilities would continue to be operated by the two units of government now providing public sanitary sewer service within the Town of Pleasant Prairie. However, both of the sanitary districts presently operating the public sanitary sewerage systems are extensions of the same town government. Based upon all of these considerations, neither alternative is clearly better. However, on the basis of lower energy use for wastewater conveyance and lesser construction requirements, the second alternative—two wastewater treatment plants to serve the Bristol-IH 94, Pleasant Prairie-North, and Pleasant Prairie-South sewer service areas—is recommended.

Alternative Plans—Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes Subareas

As noted above, alternative analyses were conducted which considered the interconnection of the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes subareas for wastewater treatment purposes. Three basic alternative plans were formulated. The first assumes the continuation of three individual sewage treatment facilities. The second provides for the abandonment of the Paddock Lake facility and the connection of the Paddock Lake sewer service area to an expanded Town of Salem Sewer Utility District No. 1 treatment facility. The third alternative provides for a single sewage treatment facility at the site of the existing Town of Salem Sewer Utility District No. 1 facility. Required sewage treatment levels and performance standards under the three alternatives are set forth in Table 145, and the three proposals are shown on Map 65, 66, and 67.

In order to meet established water use objectives for the Des Plaines River, the treatment plants proposed under each of the three alternative plans will need to provide either a secondary level of wastewater treatment followed by auxiliary waste treatment for effluent disinfection and land application of the treatment plant effluent, or secondary waste treatment with advanced and auxiliary waste treatment, including a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l total phosphorus. The recommendations regarding treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan. That plan recommended separate treatment facilities to serve each of the three subareas. For the Paddock Lake and Hooker-Montgomery Lakes sewer service area treatment plants, the regional sanitary sewerage system plan recommended the provision of secondary waste treatment plus conventional advanced waste treatment for nitrification and phosphorus removal—with an effluent concentration of 1.0 mg/l total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection. For the Bristol sewer service area, the plan recommended the provision of secondary waste treatment plus conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection.

Based upon the general analyses described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application is considered to be less costly than providing secondary waste treatment followed by a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment. Simulation model studies indicate that water quality standards for phosphorus cannot be achieved for the Des Plaines River when conventional advanced waste treatment for phosphorus removal is provided prior to discharge of the plant effluent to the surface waters. The phosphorus standard can be achieved about 90 percent of the time if land application of effluent is practiced, or if a high level of advanced waste treatment for phosphorus removal is provided prior to discharge to the surface waters, and if the appropriate level of nonpoint source pollution control is achieved. Accordingly, the effluent land application alternative is recommended. Should local facility planning efforts indicate that land applica-

Table 145

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BRISTOL-GEORGE LAKE, PADDOCK LAKE, AND HOOKER-MONTGOMERY LAKES SEWER SERVICE AREAS: DES PLAINES RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| Village of Paddock Lake | 0.36 | 0.46 | Paddock Lake | 2,800 | 3,300 | Secondary<br>Auxiliary<br><br>Advanced[b] | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Town of Salem Sewer Utility District No. 1 | 0.16 | 0.25 | Hooker-Montgomery Lakes | 1,400 | 1,800 | Secondary<br>Auxiliary<br><br>Advanced[c] | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Town of Bristol Sewer Utility District No. 1 | 0.20 | 0.32 | Bristol-George Lake | 1,400 | 2,000 | Secondary<br>Auxiliary<br><br>Advanced[d] | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Alternative Plan 2[e] | | | | | | | | |
| Town of Salem Sewer Utility District No. 1 | 0.52 | 0.71 | Paddock Lake<br>Hooker-Montgomery Lakes | 4,200 | 5,100 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 15 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Town of Bristol Sewer Utility District No. 1 | 0.20 | 0.32 | Bristol-George Lake | 1,400 | 2,000 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 15 mg/l<br>Fecal Coliform Concentration: 200/100<br>- - |
| Alternative Plan 3[e] | | | | | | | | |
| Town of Salem Sewer Utility District No. 1 | 0.72 | 1.03 | Bristol-George Lake<br>Paddock Lake<br>Hooker-Montgomery Lakes | 5,600 | 7,100 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application | $BOD_5$ Discharge: 15 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] *See Map 61.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with advanced waste treatment for nitrification and phosphorus removal followed by auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the surface waters.*

[c] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations which included the provision of secondary waste treatment followed by advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the surface waters.*

[d] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the surface waters.*

[e] *Recommended wastewater treatment levels were not specifically reported in the regional sanitary sewerage system plan for this alternative.*

*Source: SEWRPC.*

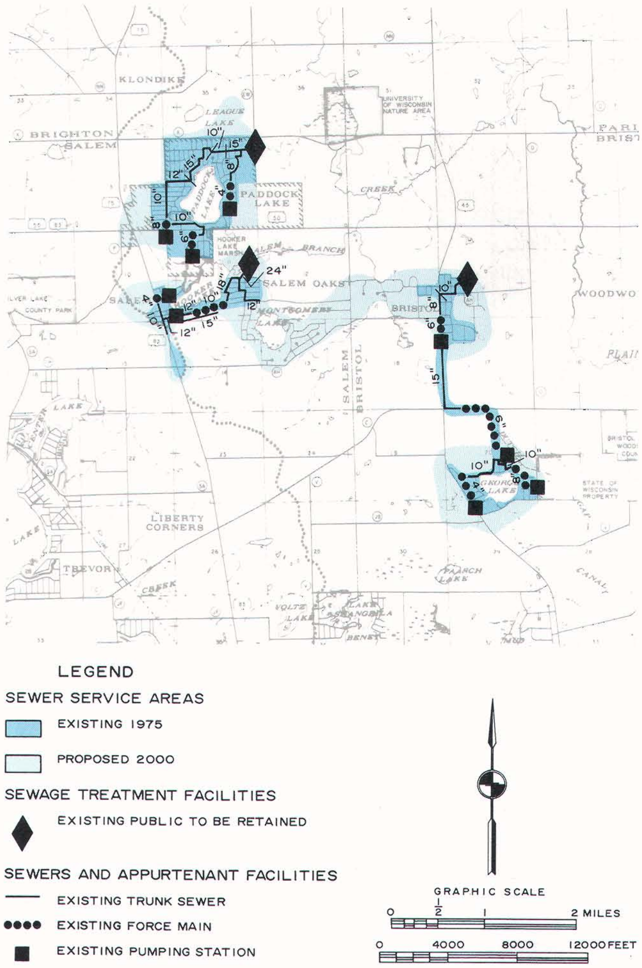
tion of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with the effluent discharged to the surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practicable level, and to ultimately reduce the total phosphorus concentration in the plant effluent to about 0.1 mg/l.

Under Alternative Plan 1, the Hooker Lake sewage treatment facility would not require expansion beyond its present average hydraulic design capacity of 0.30 mgd. It is anticipated that future growth and the inclusion of the Montgomery Lake area will require an average hydraulic design capacity of about 0.16 mgd in 1985 and about 0.25 mgd in the year 2000, still within the design capacity of the existing facility. This year 2000 design flow is slightly lower than the estimated 1990 flow of 0.27 mgd anticipated under the regional sanitary sewerage system plan.

The Paddock Lake wastewater treatment facility would be expanded under the first alternative. In 1975 the wastewater treatment facility serving the Village of Paddock Lake had an average hydraulic design capacity

## Map 65

### ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1 FOR THE BRISTOL-GEORGE LAKE, PADDOCK LAKE, AND HOOKER-MONTGOMERY LAKES SEWER SERVICE AREAS– DES PLAINES RIVER SUBREGIONAL AREA: 2000

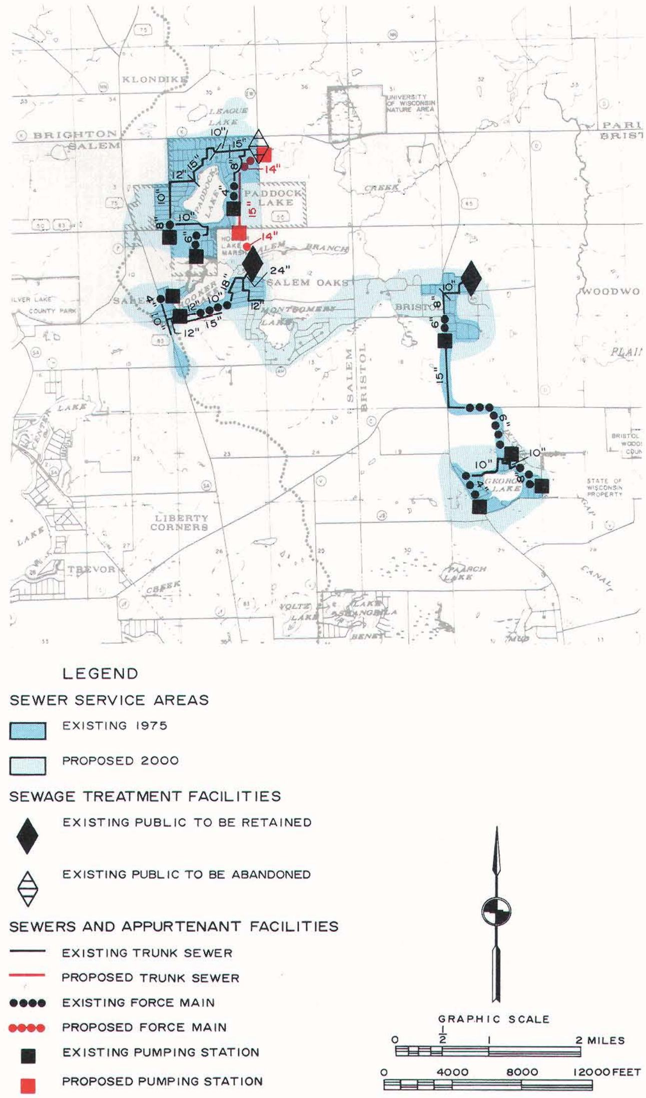



The first alternative plan considered for the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas proposes the upgrading and continued operation of the existing treatment facilities presently serving each of the three areas. The plan proposes that all three of these plants be upgraded to provide secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application of effluent, or secondary waste treatment, with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the surface waters.

*Source: SEWRPC.*

## Map 66

### ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2 FOR THE BRISTOL-GEORGE LAKE, PADDOCK LAKE, AND HOOKER-MONTGOMERY LAKES SEWER SERVICE AREAS– DES PLAINES RIVER SUBREGIONAL AREA: 2000

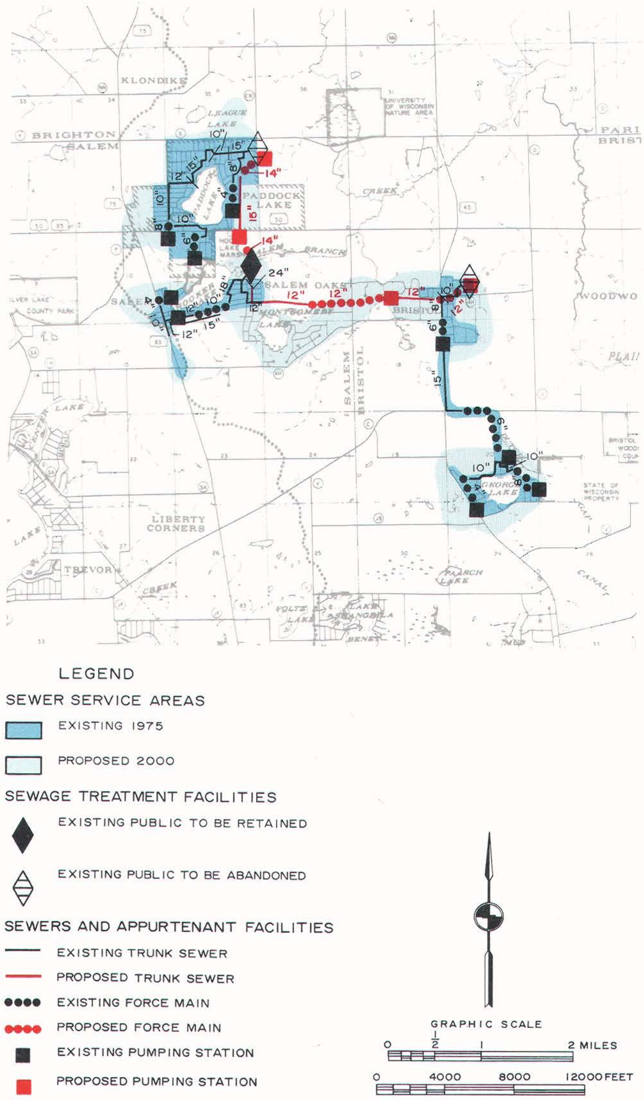



The second alternative plan considered for the Bristol-George Lake, Paddock Lake, Hooker-Montgomery Lakes sewer service areas proposes the abandonment of the existing sewage treatment plant serving the Paddock Lake sewer service area and connection of that area to the expanded plant operated by the Town of Salem Sewer Utility District No.1 serving the Hooker-Montgomery Lakes sewer service area. The existing wastewater treatment plant serving the Bristol-George Lake area would be upgraded and expanded. Both of the two treatment plants proposed under this alternative plan would provide secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application of effluent, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent disinfection prior to discharge to the surface waters.

*Source: SEWRPC.*

Map 67

**ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 3 FOR THE BRISTOL-GEORGE LAKE, PADDOCK LAKE, AND HOOKER-MONTGOMERY LAKES SEWER SERVICE AREAS— DES PLAINES RIVER SUBREGIONAL AREA: 2000**




The third alternative plan considered for the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas proposes the consolidation of all sewage treatment at the existing treatment facility operated by the Town of Salem Sewer Utility District No. 1 in the Hooker-Montgomery Lakes sewer service area. This plant would be expanded and upgraded to provide secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application of plant effluent, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the surface waters.

*Source: SEWRPC.*

of 0.32 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Paddock Lake sewer service area of about 0.36 mgd in 1985 and about 0.46 mgd in the year 2000. This year 2000 design flow is lower than the estimated 1990 flow of 0.80 mgd anticipated under the regional sanitary sewerage system plan.

Under the first alternative the Bristol wastewater treatment plant would also be expanded. In 1975 the wastewater treatment facility serving the Bristol-George Lake sewer service area had an average hydraulic design capacity of 0.16 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Bristol-George Lake sewer service area of about 0.20 mgd in 1985 and about 0.32 mgd in the year 2000. This year 2000 design flow is the same as that developed under the regional sanitary sewerage system plan.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities included under Alternative Plan 1 for the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas is about $7,118,000. The estimated capital cost for constructing the necessary additional treatment facilities is $5,661,000, with an estimated average annual operation and maintenance cost of $208,000 (see Table 146).

Alternative Plan 2 for the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas is essentially the same as Alternative Plan 1, except that the existing Paddock Lake sewage treatment facility would be abandoned and the entire Paddock Lake sewer service area connected to an expanded Town of Salem Sewer Utility District No. 1 wastewater treatment facility. The Town of Salem Sewer Utility District No. 1 wastewater treatment facility would need to be expanded from its existing 0.32 average hydraulic design capacity to a year 2000 average hydraulic design capacity of about 0.71 mgd. This alternative is expected to be similar in cost to another alternative, which would abandon the existing Hooker Lake plant and connect the Hooker-Montgomery Lakes sewer service area to an expanded Paddock Lake plant. However, for purposes of the systems analysis, it was assumed that the Paddock Lake plant would be abandoned. This alternative requires the conveyance of more wastewater from one service area to another, but removes the wastewater discharge from the marshland included in the University of Wisconsin Nature Area located in the Town of Paris, which is deemed to be of state, regional, and county significance. It further makes better use of the existing Hooker Lake plant which is newer than the Paddock Lake plant.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas is about $6,044,000. The estimated capital cost for constructing

## Table 146

## DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BRISTOL-GEORGE LAKE, PADDOCK LAKE, AND HOOKER-MONTGOMERY LAKES SEWER SERVICE AREA: DES PLAINES RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Town of Paddock Lake | | | | | | | | |
| Facilities. . . . . . . . . . . | $2,324,000 | $ 84,000 | $1,699,000 | $1,065,000 | $2,764,000 | $108,000 | $ 68,000 | $176,000 |
| Land . . . . . . . . . . . . . | 174,000 | - - | 100,000 | - - | 100,000 | 6,000 | - - | 6,000 |
| Subtotal | $2,498,000 | $ 84,000 | $1,799,000 | $1,065,000 | $2,864,000 | $114,000 | $ 68,000 | $182,000 |
| Town of Salem Sewer Utility District No. 1 | | | | | | | | |
| Facilities. . . . . . . . . . . | 1,279,000 | 60,000 | 986,000 | 916,000 | 1,902,000 | 63,000 | 58,000 | 121,000 |
| Land . . . . . . . . . . . . . | 110,000 | - - | 63,000 | - - | 63,000 | 4,000 | - - | 4,000 |
| Subtotal | $1,389,000 | $ 60,000 | $1,049,000 | $ 916,000 | $1,965,000 | $ 67,000 | $ 58,000 | $125,000 |
| Town of Bristol Sewer Utility District No. 1 | | | | | | | | |
| Facilities. . . . . . . . . . . | 1,644,000 | 64,000 | 1,237,000 | 977,000 | 2,214,000 | 78,000 | 62,000 | 140,000 |
| Land . . . . . . . . . . . . . | 130,000 | - - | 75,000 | - - | 75,000 | 5,000 | - - | 5,000 |
| Subtotal | $1,774,000 | $ 64,000 | $1,312,000 | $ 977,000 | $2,289,000 | $ 83,000 | $ 62,000 | $145,000 |
| Subtotal—Treatment Plants | $5,661,000 | $208,000 | $4,160,000 | $2,958,000 | $7,118,000 | $264,000 | $188,000 | $452,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $5,661,000 | $208,000 | $4,160,000 | $2,958,000 | $7,118,000 | $264,000 | $188,000 | $452,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plants | | | | | | | | |
| Town of Salem Sewer Utility District No. 1 | | | | | | | | |
| Facilities. . . . . . . . . . . | $2,153,000 | $ 94,000 | $1,673,000 | $1,407,000 | $3,080,000 | $106,000 | $ 89,000 | $195,000 |
| Land . . . . . . . . . . . . . | 247,000 | - - | 142,000 | - - | 142,000 | 9,000 | - - | 9,000 |
| Subtotal | $2,400,000 | $ 94,000 | $1,815,000 | $1,407,000 | $3,222,000 | $115,000 | $ 89,000 | $204,000 |
| Town of Bristol Sewer Utility District No. 1 | | | | | | | | |
| Facilities. . . . . . . . . . . | 1,689,000 | 63,000 | 1,276,000 | 974,000 | 2,250,000 | 81,000 | 62,000 | 143,000 |
| Land . . . . . . . . . . . . . | 135,000 | - - | 77,000 | - - | 77,000 | 5,000 | - - | 5,000 |
| Subtotal | $1,824,000 | $ 63,000 | $1,353,000 | $ 974,000 | $2,327,000 | $ 86,000 | $ 62,000 | $148,000 |
| Subtotal—Treatment Plants | $4,224,000 | $157,000 | $3,168,000 | $2,381,000 | $5,549,000 | $201,000 | $151,000 | $352,000 |
| Trunk Sewer | | | | | | | | |
| Paddock Lake-Salem . . . . . | 606,000 | 9,000 | 380,000 | 115,000 | 495,000 | 24,000 | 7,000 | 31,000 |
| Total | $4,830,000 | $166,000 | $3,548,000 | $2,496,000 | $6,044,000 | $225,000 | $158,000 | $383,000 |
| Alternative Plan 3 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Town of Salem Sewer Utility District No. 1 | | | | | | | | |
| Facilities. . . . . . . . . . . | $3,505,000 | $147,000 | $2,579,000 | $2,440,000 | $5,019,000 | $164,000 | $154,000 | $318,000 |
| Land . . . . . . . . . . . . . | 343,000 | - - | 197,000 | - - | 197,000 | 12,000 | - - | 12,000 |
| Subtotal | $3,848,000 | $147,000 | $2,776,000 | $2,440,000 | $5,216,000 | $176,000 | $154,000 | $330,000 |
| Trunk Sewers | | | | | | | | |
| Paddock Lake-Salem . . . . . | 606,000 | 9,000 | 380,000 | 115,000 | 495,000 | 24,000 | 7,000 | 31,000 |
| Bristol-Hooker Lake . . . . . | 835,000 | 7,000 | 539,000 | 109,000 | 648,000 | 34,000 | 7,000 | 41,000 |
| Subtotal | $1,441,000 | $ 16,000 | $ 919,000 | $ 224,000 | $1,143,000 | $ 58,000 | $ 14,000 | $ 72,000 |
| Total | $5,289,000 | $163,000 | $3,695,000 | $2,664,000 | $6,359,000 | $234,000 | $168,000 | $402,000 |

*Source: SEWRPC.*

the necessary additional facilities is $4,830,000, with an estimated average annual operation and maintenance cost of $166,000 (see Table 146).

The third alternative plan considered for the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas would consolidate all sewage treatment at the existing Town of Salem Sewer Utility District No. 1 wastewater treatment plant site. Under this alternative, the Hooker Lake plant would provide an average hydraulic plant capacity of 1.03 mgd. Trunk sewers to serve the Bristol-George Lake and Paddock Lake sewer service areas would be constructed to convey wastewater from these areas to the Hooker Lake site.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 3 for the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas is about $6,359,000. The estimated capital cost for constructing the necessary additional facilities is $5,289,000, with an estimated average annual operation and maintenance cost of $163,000 (see Table 146).

On an equivalent annual basis, Alternative Plan 2 would be about 15 percent less costly to implement than would Alternative Plan 1, and about 5 percent less costly than Alternative Plan 3. Because the costs of Alternative Plans 2 and 3 are about equal—well within the accuracy of the cost estimating procedures—plan selection must be based upon other less tangible, but nevertheless real, considerations. Alternative Plan 3 has the advantage of providing only one treatment facility to serve the three sewer service areas, thus avoiding the duplication of staff and related facilities associated with two plants serving the area. The monitoring requirements associated with the treatment facilities would also be less under Alternative Plan 3. Alternative Plan 3 has an inherent disadvantage in that it requires the conveyance of wastewater from the Bristol sewer service area to the Hooker Lake plant. The construction of this conveyance system will add to the extent of the area affected by the construction of the project. Thus, Alternative Plan 3 would affect a greater area and a greater population than would Alternative Plan 2. Also, under Alternative Plan 3 additional pumping, with its associated energy use, would be required to convey wastewater from the Bristol sewer service area to the Hooker Lake plant site. When compared to Alternative Plan 3, the second alternative has certain advantages concerning ease of implementation in that sewage treatment facilities would continue to be operated by the two units of government which are presently providing public sanitary sewer service. Based upon all of these considerations, neither alternative is clearly better. However, on the basis of lower energy use for wastewater conveyance and lesser construction requirements, the second alternative—two wastewater treatment plants to serve the Bristol-George Lake, Paddock Lake, and Hooker-Montgomery Lakes sewer service areas—is recommended.

Private Wastewater Treatment Plants

There are seven known private wastewater treatment facilities in the Des Plaines River subregional area which in general serve isolated enclaves of urban land uses and treat wastes which can be accepted in public sanitary sewerage systems. These facilities currently discharge relatively minor amounts of treated wastewaters to the streams and groundwater in the Des Plaines River subregional area. These facilities serve the Brightondale County Park in the Town of Brighton on the abandoned Bong Air ForceBase; the Fonk's Mobile Home Park No. 2 in the Town of Dover; the not yet developed George Connolly Development in the Town of Pleasant Prairie, near the intersection of IH 94 and CTH V; the Howard Johnson Motor Lodge and an adjacent automobile service station facility in the Town of Bristol along IH 94; the Kenosha Packing Company in the Town of Paris; the Paramski Mobile Home Park in the Town of Bristol near the Illinois-Wisconsin state line; and the Wisconsin Tourist Information Center operated by the Wisconsin Department of Transportation in the Town of Pleasant Prairie, also near the intersection of IH 94 and CTH V. In addition to these seven facilities, the areawide water quality management plan proposes a facility to serve the Bong Recreational Area. Plans for this new private wastewater treatment plant are being developed by the Wisconsin Department of Natural Resources.

Except for the Howard Johnson Motor Lodge facility, each of these facilities lies beyond the proposed year 2000 service areas of the public sanitary sewerage systems discussed above. These facilities accordingly must be retained and, as necessary, upgraded to provide a level of waste treatment adequate to meet the water use objectives and standards for the streams within the Des Plaines River watershed, and consistent with the treatment levels proposed for public plants discharging to the same or similar surface water systems. The Howard Johnson Motor Lodge facility would be abandoned upon implementation of the proposed sewerage system plan for the Bristol-IH 94 sewer service area. Based upon the general analysis described earlier in this chapter, land application of plant effluent is considered to be less costly and a viable alternative to providing advanced waste treatment prior to discharge to surface waters for facilities the size of the six private plants noted above to be retained. The proposed plan for these plants is based upon the provision of land application of plant effluent (see Table 147). Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered.

The estimated present worth of construction and operation of the private wastewater treatment facilities in the Des Plaines River subregional area over a 50-year analysis period is about $2,220,000. The estimated capital cost for constructing the necessary facilities is about $1,580,000 with an estimated average annual operation and maintenance cost of $65,000.

Table 147

WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE DES PLAINES RIVER SUBREGIONAL AREA

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| Brightondale County Park | Town of Brighton | Recreational | Sanitary | Soil Absorption | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Bong Recreational Area | Town of Brighton | Recreational | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Fonk's Mobile Home Park No. 2 | Town of Dover | Residential | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| George Connolly Development | Town of Pleasant Prairie | Commercial | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Kenosha Packing Company | Town of Paris | Industrial | Process, Cooling, and Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Paramski Mobile Home Park | Town of Bristol | Residential | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| Wisconsin Department of Transportation— Tourist Information Center | Town of Pleasant Prairie | Institutional | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |

*Source: SEWRPC.*

### Existing Unsewered Urban Development Outside the Proposed Sanitary Sewer Service Area

There are five enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area as shown on Map 61. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are listed in Table 148. In an alternative analysis described earlier in this chapter, the cost of providing public sewerage service to these enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that cost comparison, it was concluded that wastewater treatment for these enclaves of unsewered urban development should be provided in one of two ways.

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan proposal is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. Because the soil conditions in the Des Plaines subregional area are generally unsuitable for onsite waste disposal, none of the enclaves of urban development were determined to be in this category.

Thus, for all of the urban enclaves in the Des Plaines River subregional area, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. These areas, which should consider alternative methods of waste disposal and an intensive inspection and maintenance program for conventional systems, as well as the possibility of connection to the public sanitary sewer service areas, are the Towns of Brighton—Section 12, the Town of Pleasant Prairie—Section 6, the Town of Somers—Section 6, and Mud Lake, all in Kenosha County, and the Town of Dover—Section 36 in Racine County. These areas generally have soil conditions and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

### Sanitary System Flow Relief Devices

In 1975 there were three sanitary sewer system flow relief devices in the Des Plaines River subregional area.

Table 148

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE DES PLAINES RIVER SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population | | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | | 1975 | 2000 | |
| | Kenosha County | | | |
| 1 | Town of Brighton–Section 12 | 245 | 190 | 2.5 |
| 2 | Town of Pleasant Prairie–Section 6 | 152 | 140 | 0.9 |
| 3 | Town of Somers–Section 6 | 448 | 446 | 1.7 |
| 4 | Mud Lake | 214 | 173 | 1.3 |
| | Racine County | | | |
| 5 | Town of Dover–Section 36 | 283 | 157 | 0.4 |
| Total | | 1,342 | 1,106 | - - |

[a] *See Map 61.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

The proposed plan recommends that facilities planning efforts include the formulation of plans for the elimination of these sewage flow relief devices.

Other Known Point Sources of Wastewater

There are a total of two known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Des Plaines River subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975. It is recommended that these point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 149.

The degree of treatment and costs of constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with other pretreatment requirements for existing discharges to public sanitary sewerage systems. However, in order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area, a cost estimate was made of the treatment requirements which appeared to be needed from the limited data available on these point sources. This estimate excludes existing industrial process system modifications designed to reduce pollutant discharge, existing industrial treatment facilities, and existing pretreatment systems utilized for treatment of waste conveyed to public sanitary sewerage systems. The total present worth over a 50-year analysis period of construction and operation of the treatment facilities needed to correct existing discharges of industrial wastes is estimated to be about $123,000. The capital cost for constructing the facilities is about $100,000, with an estimated average annual cost of $3,000 over the design period 1975 to 2000.

UPPER FOX RIVER SUBREGIONAL AREA

The Upper Fox River subregional area consists of all that part of the Fox River watershed lying generally north of the Vernon Marsh in Waukesha County. This rapidly urbanizing area includes the City of Waukesha and the westerly portion of the Cities of Brookfield and New Berlin; the Villages of Pewaukee, Sussex, and Lannon and the westerly portion of the Village of Menomonee Falls; and all of the Towns of Brookfield, Pewaukee, and Waukesha and portions of the Towns of Delafield, Lisbon, and Genesee.

Centralized sanitary sewer service in the Upper Fox River subregional area was provided by four individual systems in 1975. These systems are operated by the Cities of Waukesha and Brookfield and the Villages of Pewaukee

Table 149

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION—DES PLAINES RIVER SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Bristol Water Utility . . | Town of Bristol | Intermittent | Tributary to the Des Plaines River | Suspended Solids |
| Ladish Company—Tri-Clover Division . . | Town of Pleasant Prairie | 0.094 | Tributary to the Des Plaines River | Phosphorus, Oil and Grease |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources, reports filed under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

and Sussex. The service areas of these four systems together comprised about 24.5 square miles and served an estimated population of 76,300 persons. In 1975 there were about 33,000 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the four existing systems are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Sewer Service Analysis Areas

A total of four sewer service analysis areas may be identified within the Upper Fox River subregional area (see Table 150). These four sewer service analysis areas are shown on Map 68 and may be described as follows:

1. Area A—This area consists of the Villages of Sussex and Lannon, portions of the Village of Menomonee Falls, and environs. In 1975 sanitary sewer service was provided in this area to about 1.1 square miles, having a total resident population of about 4,000 persons. The total area anticipated to be served by the year 2000 approximates 7.96 square miles, with a projected resident population of about 14,500 persons. This represents a significant decrease from the 27,200 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Sussex-Lannon" sewer service area in the ensuing discussion.
2. Area B—This area consists of the Village of Pewaukee and environs, including urban development along the shoreline of Pewaukee Lake in the Towns of Delafield and Pewaukee. In 1975 sanitary sewer service was provided only within the Village of Pewaukee to a total area of about 1.3 square miles, having a total resident population of about 4,800 persons. The total area anticipated to be served by the year 2000 approximates 7.8 square miles, with a projected resident population of nearly 17,500 persons. This represents an increase from the 15,300 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Pewaukee" sewer service area in the ensuing discussion.
3. Area C—This area consists of the westerly portion of the City of Brookfield together with portions of the Towns of Brookfield and Pewaukee, the Village of Menomonee Falls, and the City of New Berlin. In 1975 sanitary sewer service was provided in this area to about 8.5 square miles, having a total resident population of about 16,200 persons. The total area anticipated to be served by the year 2000 approximates 27.1 square miles, with a projected resident population of about 40,600 persons. This represents a decrease from the 49,100 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Brookfield-New Berlin" sewer service area in the ensuing discussion.

Table 150

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE UPPER FOX RIVER SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Population Served | Design Hydraulic Loading (mgd) |
| A | Sussex-Lannon . . . . . . | 1.06 | 4,000 | 0.47 | 4,900 | 10,800 | 1.90[b] | 7.96 | 14,500 | 2.68[b] |
| B | Pewaukee . . . . . . . . . | 1.31 | 4,800 | 0.48 | 4,600 | 12,000 | 2.03[c] | 7.79 | 17,500 | 3.15[c] |
| C | Brookfield-New Berlin . . | 8.50 | 16,200 | 2.49 | 8,200 | 29,400 | 5.20[d] | 27.11 | 40,600 | 7.61[d] |
| D | Waukesha . . . . . . . . . | 13.59 | 51,300 | 9.90 | 3,600 | 62,900 | 12.37[e] | 25.53 | 77,900 | 15.49[e] |
| | Total | 24.46 | 76,300 | 13.34 | 21,300 | 114,800 | 21.50 | 68.39 | 150,500 | 28.93 |

[a] *See Map 68.*

[b] *Includes an estimated contribution from the Willow Springs Mobile Home Park.*

[c] *Includes an estimated contribution from the Oakton Manor-Tumblebrook Golf Course.*

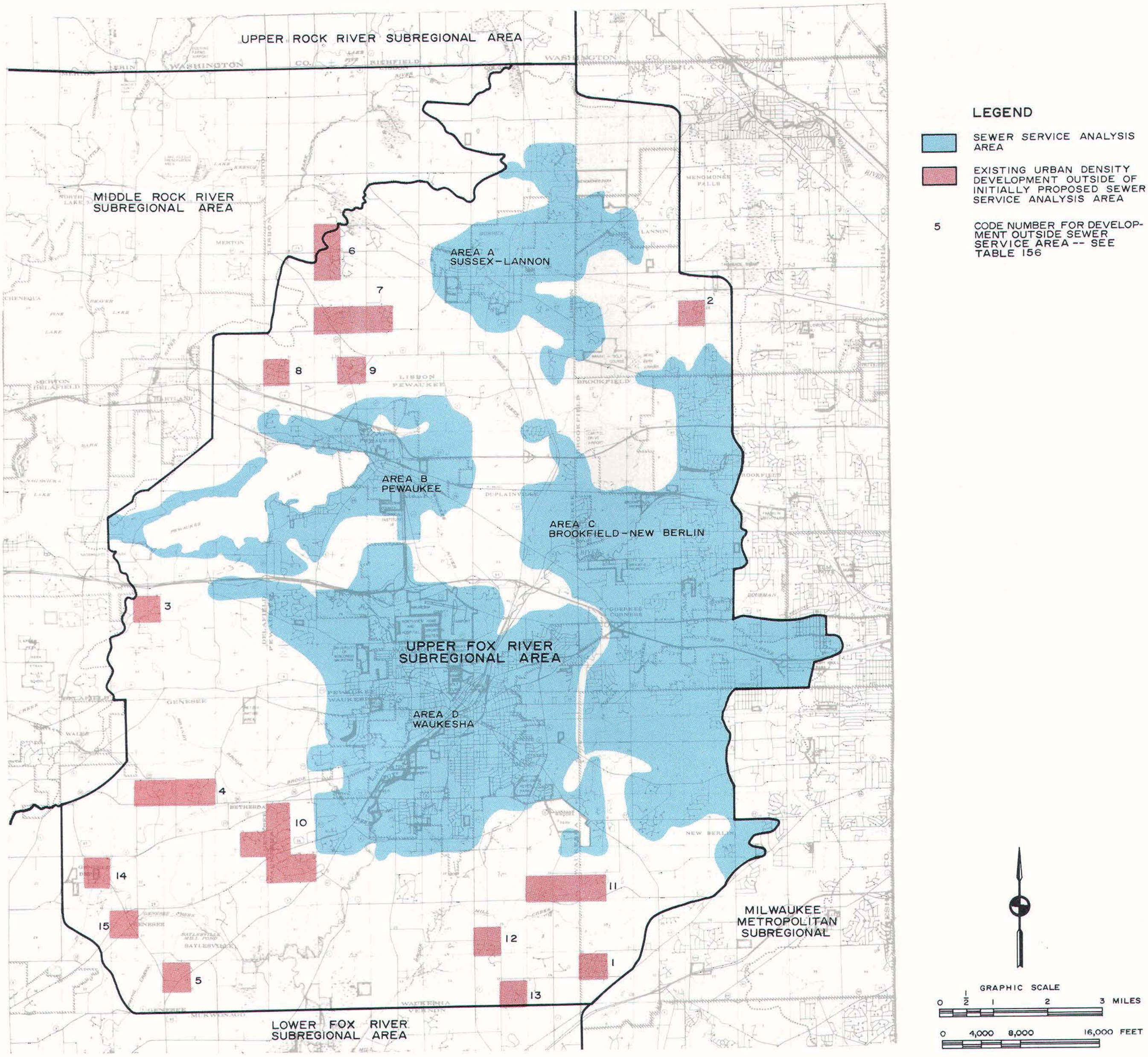
[d] *Includes an estimated contribution from New Berlin High School.*

[e] *Includes an estimated contribution from the Steeplechase Inn.*

*Source: SEWRPC.*

Map 68

SEWER SERVICE ANALYSIS AREAS: UPPER FOX RIVER SUBREGIONAL AREA




The rapidly urbanizing Upper Fox River watershed may be divided into four sanitary sewer service areas: the Sussex-Lannon area, the Pewaukee area, the Western Brookfield-New Berlin area, and the Waukesha area. By the year 2000, about 150,500 persons are expected to reside in these four sewer service areas, which will approximate 68.39 square miles. In 1975 there were about 109,300 persons residing in the Upper Fox River subregional area, of which 76,300 were served by centralized sewer service and 33,000 by onsite sewage disposal systems.

*Source: SEWRPC.*

4. Area D—This area consists of the City of Waukesha and environs, including portions of the Towns of Brookfield, Pewaukee, and Waukesha. In 1975 sanitary sewer service was provided in this area to about 13.6 square miles, having a total resident population of about 51,300 persons. The total area anticipated to be served by the year 2000 approximates 25.5 square miles, with a projected resident population of nearly 77,900 persons. This represents a decrease from the 83,200 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Waukesha" sewer service area in the ensuing discussion.

Summary of Previously Prepared Regional Plan Elements

The Fox River watershed plan, as adopted in June 1970 by the Regional Planning Commission, contained specific recommendations pertaining to sewerage system development and stream water quality management for the Upper Fox River subregional area. These recommendations were developed from a detailed examination of seven basic alternative stream water quality management plan elements for the entire watershed.

Following the preparation and adoption of the Fox River watershed plan, several developments occurred which necessitated a reevaluation of the recommendations in the adopted plan prior to their integration into the regional sanitary sewerage system plan. These developments resulted in an amendment to the Fox River watershed plan, which included a revised number of recommended treatment facilities to ultimately serve the existing and anticipated urban development in the upper Fox River watershed. The revised recommendation, which called for two major sewage treatment facilities to serve the entire upper watershed—one at Waukesha and one at Brookfield—was incorporated into the regional sanitary sewerage system plan. Because of the extensive consideration of alternative sanitary sewerage system plans under the Fox River watershed study, further detailed alternative analyses were not conducted under the regional sanitary sewerage system plan, and only a recommended plan was presented. This plan consisted of the basic stream water quality management recommendations included in the adopted Fox River watershed plan, modified to reflect the results of the reevaluation under the regional sanitary sewerage system planning program.

Formulation of Alternatives

Several local planning efforts have taken place which represent steps toward the implementation of the Upper Fox River watershed water quality management recommendations of the Fox River watershed plan and the regional sanitary sewerage system plan. The local facility planning has been completed for the Waukesha sewer service area and essentially concurs with the recommendations of the regional sanitary sewerage system plan with regard to sewer service area. The construction of additions to the Waukesha treatment facility are expected to begin early in 1979. In July 1978 the City of Brookfield initiated a facilities planning program for the Brookfield-New Berlin, Lannon-Menomonee Falls, Sussex-Lannon, and Pewaukee sewer service areas. The local facilities plans providing for the wastewater conveyance facilities needed to connect the Pewaukee sewer service area to the Brookfield plant have also been completed, and detailed plans and specifications for the project were completed in 1978. Also, in 1978 the Village of Sussex had nearly completed the construction of an addition to its existing wastewater treatment facility to provide for interim growth until a timely connection to the Brookfield sewer service area can be achieved. In view of these developments, it was concluded that the recommendations of the regional sanitary sewerage system plan with regard to the number and location of the public treatment facilities in the Upper Fox River subregional area should be incorporated into the areawide water quality management plan without further alternative consideration. Thus, with regard to the number and location of wastewater treatment plants, only the recommended plan for sanitary sewerage in the Upper Fox River subregional area as developed under the regional sanitary sewerage system plan is described herein, with certain modifications indicated as desirable by subsequent system and facilities planning efforts. Alternatives are evaluated with regard to the type of treatment system to be utilized. Results of water quality simulations are presented under the previous section on the diffuse source control element recommendations for the Fox River watershed. The alternative plans for the four sewer service areas that lie within the Upper Fox River subregional area are described in the following sections.

Alternative Plans—Waukesha Subarea

In 1975 the wastewater treatment facility serving the Waukesha sewer service area had an average hydraulic design capacity of about 8.5 mgd, and provided a secondary level of waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Waukesha sewer service area of about 12.4 mgd in 1985 and about 15.5 mgd in the year 2000. This year 2000 flow is somewhat lower than the estimated 1990 design flow of 17.5 mgd anticipated under the regional sanitary sewerage system plan.

As previously noted, the City of Waukesha had completed facilities planning for the construction of major modifications to upgrade and expand the City's wastewater treatment plant. The plant is being designed to provide secondary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent disinfection. The plant is proposed to have an average hydraulic design capacity of 16 mgd. Detailed plans and specifications for this proposed project were completed as of July 1978, with construction expected to begin early in 1979.

In order to meet the established water use objectives for the Fox River, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of the plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. The regional sanitary sewerage system plan recommended that the plant effluent have a total phosphorus concentration of 1.0 mg/l, while the updated recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analysis described earlier in this chapter, the effluent land application alternative and the treatment and discharge alternative should be considered further in the alternative analyses for a plant the size of the Waukesha facility. Accordingly, two treatment alternatives were considered for the Waukesha sewer service area. The first alternative would provide for continued discharge of the Waukesha wastewater treatment plant effluent to the Fox River following the required levels of waste treatment. The second alternative assumes the provision of a land application system for disposal of secondary treatment plant effluent from the Waukesha wastewater treatment facility. The recommended wastewater treatment plant performance standards for both alternatives are set forth in Table 151, and the two proposals are shown on Map 69.

The first alternative is based upon the provision of secondary waste treatment with advanced waste treatment for ammonia-nitrogen and phosphorus removal, and would utilize conventional chemical treatment for phosphorus removal, biological secondary treatment and nitrification utilizing trickling filters, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to the Fox River. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Waukesha sewer service area is about $32,402,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $14,238,000, with an estimated average annual operation and maintenance cost of $1,442,000 (see Table 152).

The second alternative treatment system is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural lands in the Towns of Delafield, Genesee, Waukesha, and Pewaukee were selected to receive the effluent from the Waukesha wastewater treatment facility. These sites would require that the effluent be pumped about 27,000 feet. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Waukesha sewer service area is about $41,435,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $43,507,000, with an esti-

Table 151

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WAUKESHA SEWER SERVICE AREA: UPPER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Waukesha | 12.4 | 15.5 | Waukesha | 62,900 | 77,900 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of Waukesha | 12.4 | 15.5 | Waukesha | 62,900 | 77,900 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

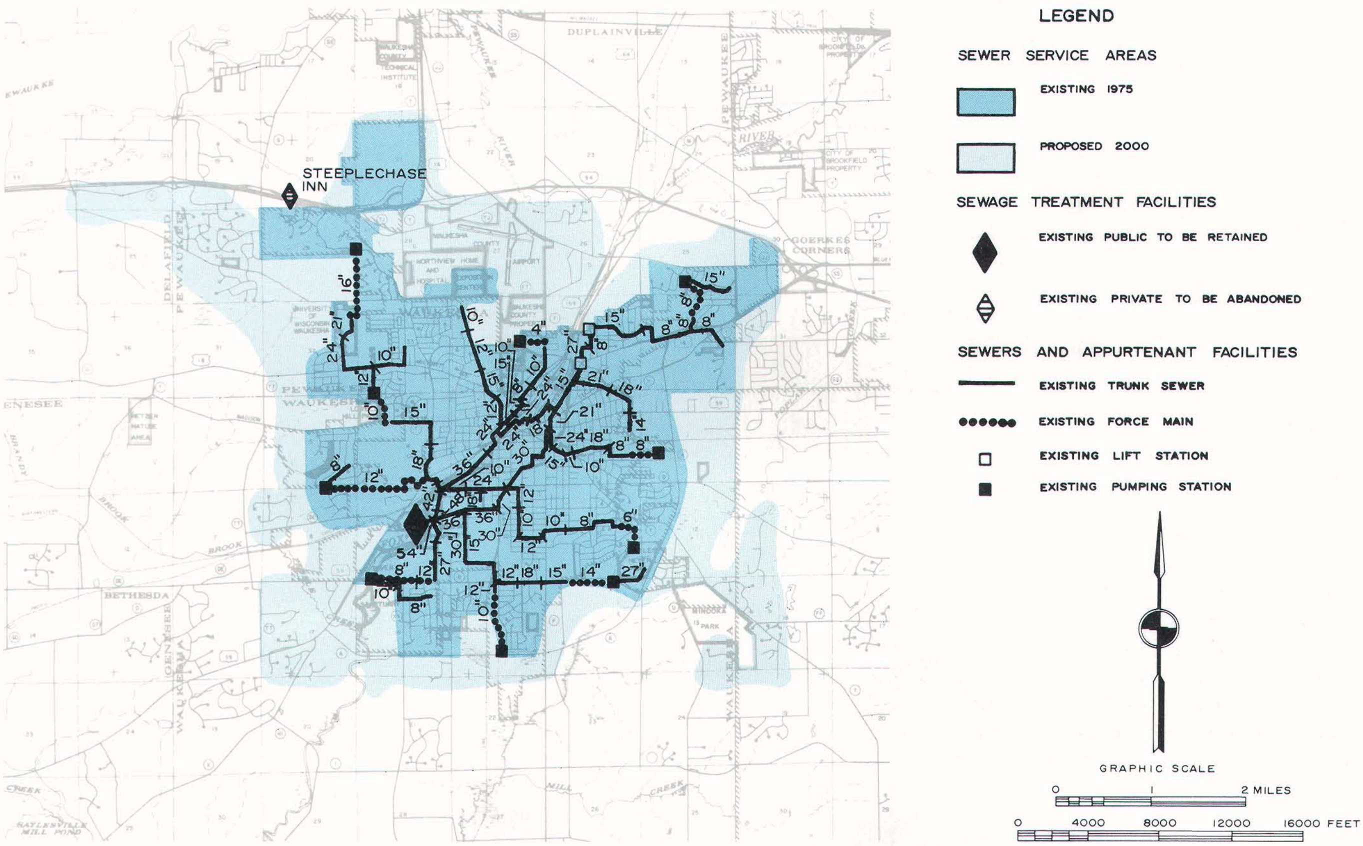
[a] *See Map 68.*

[b] *This treatment recommendation differs from the regional sanitary sewage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.*

*Source: SEWRPC.*

Map 69

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WAUKESHA SEWER SERVICE AREA: UPPER FOX RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the existing Waukesha wastewater treatment facility be expanded to serve the year 2000 sewer service area. In order to meet the established water use objectives for the Fox River watershed, it will be necessary for this facility to provide secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River. The alternative calling for the provision of advanced waste treatment levels prior to discharge to surface waters would be less costly than the effluent land application alternative, and more closely reflects local planning efforts. Construction to provide additional hydraulic capacity, as well as secondary waste treatment and conventional advanced waste treatment for nitrification and phosphorus removal, is scheduled to begin early in 1979.

*Source: SEWRPC.*

mated average annual operation and maintenance cost of $765,000 (see Table 152).

On an equivalent annual cost basis, including the cost associated with the sludge-related facilities required under the first alternative, Alternative Plan 1 would be about 14 percent less costly to implement than would Alternative Plan 2. However, there are other less tangible, but nevertheless real, factors which should be considered. Alternative Plan 1 could be more readily implemented since planning for most of the major components of the alternative is complete, and since this alternative represents a continuation of existing practices with the added construction and operational requirements for expansion and upgrading of the level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 4,400 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management. Alternative Plan 2 also requires the construction of a major conveyance system to transport the treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1.

Table 152

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WAUKESHA SEWER SERVICE AREA: UPPER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alterantive Plan 1 | | | | | | | | |
| Wastewater Treatment Plant[a] City of Waukesha . . . . . . . | $14,238,000 | $ 1,442,000 | $10,764,000 | $21,638,000 | $32,402,000 | $ 682,000 | $1,373,000 | $2,055,000 |
| Trunk Sewers—None . . . . . . | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $14,238,000 | $1,442,000 | $10,764,000 | $21,638,000 | $32,402,000 | $ 682,000 | $1,373,000 | $2,055,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant City of Waukesha | | | | | | | | |
| Facilities. . . . . . . . . . . | $39,558,000 | $ 765,000 | $28,782,000 | $10,390,000 | $39,172,000 | $1,825,000 | $ 659,000 | $2,484,000 |
| Land . . . . . . . . . . . . . | 3,949,000 | - - | 2,263,000 | - - | 2,263,000 | 144,000 | - - | 144,000 |
| Subtotal | $43,507,000 | $ 765,000 | $31,045,000 | $10,390,000 | $41,435,000 | $1,969,000 | $ 659,000 | $2,628,000 |
| Trunk Sewers—None . . . . . . | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $43,507,000 | $ 765,000 | $31,045,000 | $10,390,000 | $41,435,000 | $1,969,000 | $ 659,000 | $2,628,000 |

[a] *This alternative does not include the cost of additional facilities for increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the additional sludge-handling and -disposal requirements is $3,400,000. The estimated capital cost for construction of the added sludge-related facilities is $2,270,000, with an estimated average annual operation and maintenance cost of $117,000 over the design period 1975-2000.*

*Source: SEWRPC.*

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from the wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, based on the economic advantage, environmental impacts, and ease of implementation, Alternative Plan 1—the treatment and surface water discharge alternative—is recommended.

<u>Alternative Plans—Brookfield-New Berlin, Sussex-Lannon, and Pewaukee Subareas</u>

The proposed plan for the Brookfield-New Berlin, Sussex-Lannon, and Pewaukee sewer service areas proposes that the Sussex-Lannon and Pewaukee sewer service areas be served by the Brookfield wastewater treatment facility, with the concurrent abandonment of the existing Pewaukee and Sussex wastewater treatment facilities.

In 1975 the wastewater treatment facility serving the Brookfield sewer service area had an average hydraulic design capacity of about 5.00 mgd, and provided a secondary level of waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth and connections with the Sussex-Lannon and Pewaukee subareas will require an average hydraulic design capacity for the combined Brookfield-New Berlin, Sussex, and Pewaukee subareas of about 9.1 mgd in 1985 and about 13.4 mgd in the year 2000. This year 2000 flow is substantially lower than the estimated 1990 design flow of 19.1 mgd anticipated under the regional sanitary sewerage system plan.

As previously noted, the City of Brookfield has initiated a local facilities planning program for expansion and upgrading of sanitary sewerage facilities. The study area for that facility plan includes the Sussex-Lannon and Pewaukee sewer service areas in addition to the Brookfield-New Berlin sewer service area.

In order to meet the established water use objectives for the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of the plan effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. The regional sanitary sewerage system plan recommended that the Brookfield plant effluent have a total phosphorus concentration of 1.0 mg/l, while the updated recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analyses described earlier in this chapter, the effluent land application alternative and the treatment and discharge alternative should be considered further in the alternative analyses for a plant the size of the Brookfield facility. Accordingly, two treatment alternatives were considered for the Brookfield-New Berlin, Sussex-Lannon, and Pewaukee sewer service areas. The first alternative would provide for continued discharge of the Brookfield wastewater treatment plant effluent to the Fox River following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the provision of a land application system for disposal of secondary treatment plant effluent from the Brookfield wastewater treatment facility.

Both alternative plans provide for trunk sewers to connect the Sussex-Lannon, Pewaukee, and New Berlin areas to the Brookfield sewage treatment plant. The recommended wastewater treamtment plant performance standards for both alternatives are set forth in Table 153, and the two proposals are shown on Map 70.

Alternative Plan 1 is based upon the provision of secondary waste treatment with advanced waste treatment for ammonia-nitrogen and phosphorus removal, and would utilize conventional chemical treatment for phosphorus removal, biological secondary treatment and nitrification, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to the Fox River. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Brookfield-New Berlin, Sussex-Lannon, and Pewaukee sewer service areas is about $33,508,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $26,035,000, with an estimated average annual operation and maintenance cost of $1,047,000 (see Table 154).

Alternative Plan 2 is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural lands in the Towns of Lisbon and Pewaukee were selected to receive the effluent from the Brookfield wastewater treatment facility. These sites would require that the effluent be pumped about 25,000 feet. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative

Table 153

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BROOKFIELD-NEW BERLIN, SUSSEX-LANNON, AND PEWAUKEE SEWER SERVICE AREAS: UPPER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for *Cost Analysis* Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Brookfield | 9.1 | 13.4 | Brookfield-New Berlin, Sussex-Lannon, and Pewaukee | 50,500 | 68,700 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of Brookfield | 9.1 | 13.4 | Brookfield-New Berlin, Sussex-Lannon, and Pewaukee | 50,500 | 68,700 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br><br>- - |

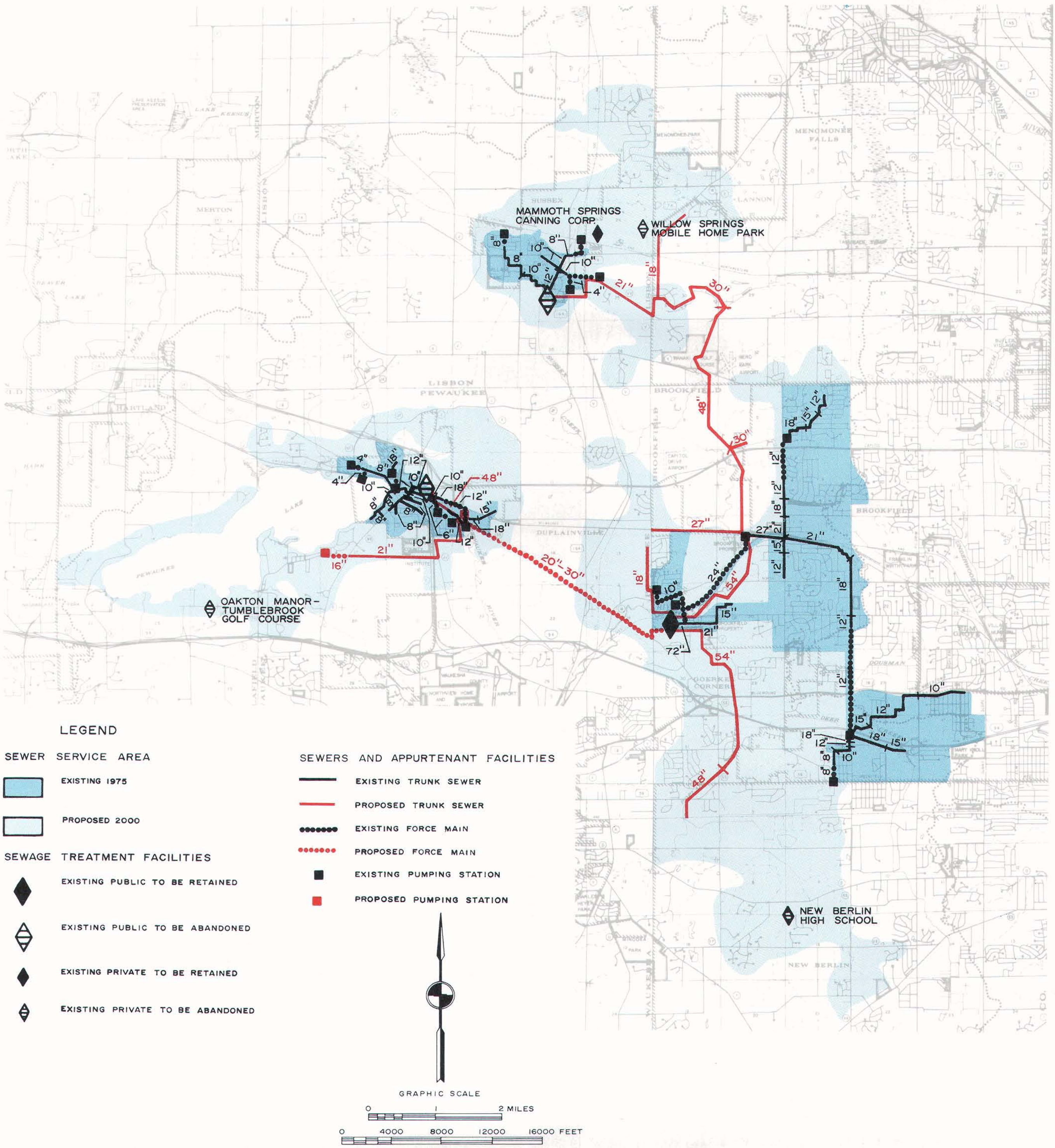
[a] *See Map 68.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.*

*Source: SEWRPC.*

## Map 70

### ALTERANTIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BROOKFIELD-NEW BERLIN, SUSSEX-LANNON, AND PEWAUKEE SEWER SERVICE AREAS—UPPER FOX RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the existing Brookfield wastewater treatment facility be expanded to serve the year 2000 sewer service areas of Brookfield-New Berlin, Sussex-Lannon, and Pewaukee. The Villages of Sussex and Pewaukee currently depend on local facilities for wastewater treatment. It is proposed that these facilities be abandoned during the plan implementation period, and that wastewater be conveyed to the regional facility at Brookfield. In order to meet the established water use objectives for the Fox River watershed, it will be necessary for this facility to provide secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River. The alternative calling for the provision of advanced waste treatment levels prior to discharge to surface waters would be less costly than the effluent land application alternative.

*Source: SEWRPC.*

Table 154

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BROOKFIELD-NEW BERLIN, SUSSEX-LANNON, AND PEWAUKEE SEWER SERVICE AREAS: UPPER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Brookfield | $12,989,000 | $1,024,000 | $ 9,822,000 | $15,184,000 | $25,006,000 | $ 623,000 | $963,000 | $1,586,000 |
| Trunk Sewers | | | | | | | | |
| Duplainville | 229,000 | 500 | 144,000 | 7,000 | 151,000 | 9,000 | 400 | 9,400 |
| Sussex-Lannon | 965,000 | 800 | 605,000 | 10,000 | 615,000 | 38,000 | 600 | 38,600 |
| Lannon-Menomonee Falls | 4,164,000 | 2,600 | 2,612,000 | 34,000 | 2,646,000 | 166,000 | 2,000 | 168,000 |
| Springdale | 327,000 | 600 | 205,000 | 9,000 | 214,000 | 13,000 | 600 | 13,600 |
| Pewaukee-Brookfield | 3,461,000 | 13,000 | 2,171,000 | 173,000 | 2,344,000 | 138,000 | 11,000 | 149,000 |
| Poplar Creek | 2,691,000 | 1,400 | 1,688,000 | 18,000 | 1,706,000 | 107,000 | 1,000 | 108,000 |
| Pewaukee Lake-Pewaukee | 1,209,000 | 5,000 | 759,000 | 67,000 | 826,000 | 48,000 | 4,000 | 52,000 |
| Subtotal | $13,046,000 | $ 23,900 | $ 8,184,000 | $ 318,000 | $ 8,502,000 | $ 519,000 | $ 19,600 | $ 538,600 |
| Total | $26,035,000 | $1,047,900 | $18,006,000 | $15,502,000 | $33,508,000 | $1,142,000 | $982,600 | $2,124,600 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Brookfield | | | | | | | | |
| Facilities | $31,118,000 | $ 702,000 | $22,826,000 | $10,841,000 | $33,667,000 | $1,448,000 | $688,000 | $2,136,000 |
| Land | 3,330,000 | -- | 1,908,000 | -- | 1,908,000 | 121,000 | -- | 121,000 |
| Subtotal | $34,448,000 | $ 702,000 | $24,734,000 | $10,841,000 | $35,575,000 | $1,569,000 | $688,000 | $2,257,000 |
| Trunk Sewers | | | | | | | | |
| Duplainville | $ 229,000 | 500 | 144,000 | 7,000 | 151,000 | 9,000 | 400 | 9,400 |
| Sussex-Lannon | 965,000 | 800 | 605,000 | 10,000 | 615,000 | 38,000 | 600 | 38,600 |
| Lannon-Menomonee Falls | 4,164,000 | 2,600 | 2,612,000 | 34,000 | 2,646,000 | 166,000 | 2,000 | 168,000 |
| Springdale | 327,000 | 600 | 205,000 | 9,000 | 214,000 | 13,000 | 600 | 13,600 |
| Pewaukee-Brookfield | 3,461,000 | 13,000 | 2,171,000 | 173,000 | 2,344,000 | 138,000 | 11,000 | 149,000 |
| Poplar Creek | 2,691,000 | 1,400 | 1,688,000 | 18,000 | 1,706,000 | 107,000 | 1,000 | 108,000 |
| Pewaukee Lake-Pewaukee | 1,209,000 | 5,000 | 759,000 | 67,000 | 826,000 | 48,000 | 4,000 | 52,000 |
| Subtotal | $13,046,000 | $ 23,900 | $ 8,184,000 | $ 318,000 | $ 8,502,000 | $ 519,000 | $ 19,600 | $ 538,600 |
| Total | $47,494,000 | $ 725,900 | $32,918,000 | $11,159,000 | $44,077,000 | $2,088,000 | $707,600 | $2,795,600 |

[a] *This alternative does not include the cost of additional facilities for increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the additional sludge-handling and -disposal requirements is $2,930,000. The estimated capital cost for construction of the added sludge-related facilities is $2,160,000, with an estimated average annual operation and maintenance cost of $88,000 over the design period 1975-2000.*

*Source: SEWRPC.*

Plan 2 for the Brookfield-New Berlin, Sussex-Lannon, and Pewaukee sewer service areas is about $44,077,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $47,494,000, with an estimated average annual operation and maintenance cost of $725,900 (see Table 154).

On an equivalent annual cost basis, including the cost of sludge-related facilities required under the first alternative, Alternative Plan 1 would be about 24 percent less costly to implement than would Alternative Plan 2. However, there are other less tangible, but nevertheless real, factors which should be considered. Alternative Plan 1 could be more readily implemented since planning or construction of most of the major components of the alternative is complete or in progress, and since this alternative represents a continuation of existing practices with the added construction and operational requirements for expansion and upgrading of the level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire a site or make other institutional arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 3,700 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management. Alternative Plan 2 also requires the construction of a major conveyance system to transport the treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1.

Although there would be greater wastewater pumping requirements under Alternative Plan 2 for conveyance of wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from the wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, based on the economic advantage, environmental impacts, and ease of implementation, Alternative Plan 1—the treatment and surface water discharge alternative—is recommended.

Private Wastewater Treatment Plants

There are five known private wastewater treatment facilities in the Upper Fox River subregional area which in general serve isolated enclaves of urban land uses and treat wastes which can be accepted in public sanitary sewerage systems. These facilities currently discharge relatively minor amounts of treated wastewater to the streams and groundwater in the Upper Fox River subregional area. These five facilities serve the Mammoth Springs Canning Corporation in the Town of Lisbon; the New Berlin High School in the City of New Berlin; the Oakton Manor-Tumblebrook Golf Course in the Town of Delafield; the Steeplechase Inn in the Town of Pewaukee; and the Willow Springs Mobile Home Park in the Town of Lisbon. All five of these facilities lie within or immediately adjacent to the proposed year 2000 service areas of the public sanitary sewerage systems discussed above. Consequently, it is proposed that the New Berlin High School be connected to the Brookfield-New Berlin sewer service area and abandon its wastewater treatment facility; that the Oakton Manor-Tumblebrook Golf Course be connected to the Pewaukee sewer service area and abandon its wastewater treatment facility; that the Steeplechase Inn be connected to the Waukesha sewer service area and abandon its wastewater treatment facility; and that the Willow Springs Mobile Home Park be connected to the Sussex-Lannon sewer service area and abandon its wastewater treatment facility. Although located within the Sussex sewer service area, the Mammoth Springs Canning Corporation facility is recommended to be retained because it is a specialized treatment facility constructed to treat canning wastes and includes extensive spray irrigation facilities. The standards established for the Mammoth Springs Canning Corporation treatment facility assume the continuation of the spray irrigation system (see Table 155). The estimated present worth of construction and operation of this single private wastewater treatment facility in the Upper Fox River subregional area over a 50-year analysis period is $491,000. The estimated capital cost for constructing the necessary facilities is $170,000, with an estimated average annual operation and maintenance cost of $23,000 over the design period 1975 to 2000.

Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are 14 enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area, as shown on Map 68. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are listed in Table 156. In a generalized alternative analysis described earlier in this chapter, the cost of providing public sewerage service to these enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that comparison, it was concluded that wastewater treatment for these enclaves of unsewered urban development should be provided in one of two ways.

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan proposal is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. Eleven of the 14 unsewered urban enclaves were in this category—the City of New Berlin—Section 31; the Village of Menomonee Falls—Section 28; the Town of Delafield—Section 27; the Town of Genesee—Sections 10 and 11, and Section 35; the Town of Lisbon—Section 20, Sections 28 and 29, and Section 31; the Town of Waukesha—Sections 18 and 19 and the Town of Delafield—Section 13; the Town of Waukesha—Section 24 and the City of New Berlin—Section 19; and the Town of Waukesha—Section 26, all in Waukesha County.

For the remaining enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. The three urban enclaves which should consider alternative methods of onsite waste disposal and an intensive inspection and maintenance program for conventional systems, as well

Table 155

WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE UPPER FOX RIVER SUBREGIONAL AREA

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| Mammoth Springs Canning Corporation | Town of Lisbon | Industrial | Process | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

Source: SEWRPC.

Table 156

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE UPPER FOX RIVER SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population | | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | | 1975 | 2000 | |
| | Waukesha County | | | |
| 1 | City of New Berlin—Section 31 | 724 | 546 | 0.4 |
| 2 | Village of Menomonee Falls—Section 28 | 423 | 340 | 0.4 |
| 3 | Town of Delafield—Section 27 | 102 | 191 | 1.1 |
| 4 | Town of Genesee—Sections 10 and 11 | 492 | 875 | 0.8 |
| 5 | Town of Genesee—Section 35 | 145 | 123 | 1.8 |
| 6 | Town of Lisbon—Section 20 | 220 | 362 | 1.5 |
| 7 | Town of Lisbon—Sections 28 and 29 | 420 | 607 | 1.9 |
| 8 | Town of Lisbon—Section 31 | 275 | 448 | 0.5 |
| 9 | Town of Lisbon—Section 32 | 143 | 269 | 1.0 |
| 10 | Town of Waukesha—Sections 18 and 19 Town of Delafield—Section 13 | 336 | 1,078 | - - |
| 11 | Town of Waukesha—Section 24 City of New Berlin—Section 19 | 425 | 577 | 0.6 |
| 12 | Town of Waukesha—Section 26 | 104 | 170 | 1.7 |
| 13 | Town of Waukesha—Section 35 | 104 | 166 | 1.9 |
| 14 | Genesee | 165 | 165 | 0.4 |
| 15 | Genesee Depot | 198 | 205 | 1.0 |
| Total | | 4,276 | 6,122 | - - |

[a] *See Map 68.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

as the possibility of connection to the public sanitary sewer service area, are the Town of Lisbon—Section 32, Genesee, and Genesee Depot, all in Waukesha County. The above areas generally have soil conditions and lot sizes considered unsuitable for conventional methods of onsite wastewater treatment.

Sanitary Sewer System Flow Relief Devices

In 1975 there were 13 sanitary sewer system flow relief devices in the Upper Fox River subregional area. The proposed plan recommends that facilities planning efforts include the formulation of plans for the elimination of these flow relief devices.

Other Known Point Sources of Wastewater

There are a total of 20 known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Upper Fox River subregional area. These point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of five-day biochemical oxygen demand ($BOD_5$), ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar surface water bodies. Thus, in most cases no further treatment recommendations were advanced for these other point sources with regard to these constituents, and there are no connections to sewerage service areas recommended. However, it is recommended that these point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 157.

The degree of treatment and costs of constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with other pretreatment requirements for existing discharges to public sanitary sewerage systems. However, in order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area, a cost estimate was made of the treatment requirements which appeared to be needed from the limited data available on these point sources. This estimate excludes existing and proposed industrial process system modification designed to reduce pollutant discharge, existing industrial treatment facilities, and existing pretreatment systems utilized for treatment of waste conveyed to public sanitary sewerage systems. The total present worth over a 50-year analysis period of construction and operation of the treatment facilities needed to correct existing discharges of industrial wastes is estimated to be about $348,000. The capital cost for constructing the facilities is about $272,000, with an estimated average annual cost of $9,000 over the design period 1975 to 2000.

Table 157

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION—UPPER FOX RIVER SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| International Harvester Company. . | City of Waukesha | 0.018 | Fox River via Storm Sewer | Suspended Solids |
| Mammoth Springs Canning Corporation. . . . . . . . | Town of Lisbon | 0.001 | Sussex Creek | Suspended Solids |
| Payne & Dolan of Wisconsin, Inc.. . | Town of Pewaukee | 0.922 | Fox River | Suspended Solids |
| Halquist Stone Company, Inc.. . . . | Town of Lisbon | 1.186 | Sussex Creek | Suspended Solids |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System, reports filed under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

## LOWER FOX RIVER SUBREGIONAL AREA

The Lower Fox River subregional area consists of all that part of the Fox River watershed lying generally south of the Vernon Marsh in Waukesha County. The Lower Fox River subregional area is comprised of all or portions of several subwatersheds, including the Mukwonago River subwatershed, the Honey Creek subwatershed, the Sugar Creek subwatershed, and the White River subwatershed. Concentrations of urban development are found in the Cities of Burlington and Lake Geneva and in the Villages of Mukwonago, East Troy, Rochester, Waterford, Silver Lake, Twin Lakes, and Genoa City. In addition, urban development is located along the shorelines of several major lakes, including Wind Lake, Waubesee Lake, Lake Denoon, Tichigan Lake, Browns Lake, Potter Lake, Eagle Lake, Lake Como, and Camp and Center Lakes.

Centralized sanitary sewer service in the Lower Fox River subregional area was provided by eight systems in 1975: those operated by the Cities of Burlington and Lake Geneva; the Villages of East Troy, Genoa City, Mukwonago, Silver Lake, and Twin Lakes; and the Western Racine County Sewerage District serving the Villages of Rochester and Waterford and a portion of the Town of Rochester. Together, the service areas of these eight systems comprised about 11.1 square miles and served an estimated population of 31,300 persons. In 1975 there were about 54,100 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the eight existing systems are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

### Sewer Service Analysis Areas

A total of 19 sewer service analysis areas may be identified within the Lower Fox River subregional area (see Table 158). These 19 sewer service analysis areas are shown on Map 71 and may be described as follows:

1. Area A—This area consists of the Village of Mukwonago and environs. In 1975 sanitary sewer service was provided in this area to about 1.3 square miles, having a total resident population of about 3,400 persons. The total area anticipated to be served by the year 2000 approximates 4.2 square miles, with a projected resident population of about 9,200 persons. This represents an increase in planned population from the 7,800 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Mukwonago" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Village of East Troy and environs. In 1975 sanitary sewer service was provided in this area to about 0.8 square mile, having a total resident population of about 2,200 persons. The total area anticipated to be served by the year 2000 approximates 2.5 square miles, with a projected resident population of about 5,100 persons. This represents an increase in planned population from the 3,600 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "East Troy" sewer service area in the ensuing discussion.

3. Area C—This area consists of urban development along the shoreline of Potter Lake in the Town of East Troy. About 1,100 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The East Troy Sanitary District No. 2 has been formed to provide centralized sanitary sewer service to this concentration of urban development. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 0.8 square mile, with a projected resident population of about 1,600 persons, including an estimated seasonal resident population of about 2000 persons. This represents an increase in the planned population from the 1,100 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Potter Lake" sewer service area in the ensuing discussion.

4. Area D—This area consists of the City of Lake Geneva and environs, including urban development along the shoreline of Lake Geneva in the Towns of Linn and Geneva. In 1975 sanitary sewer service was provided in this area to about 2.0 square miles, having a total resident population of about 5,700 persons. The total area anticipated to be served by the year 2000 approximates 7.4 square miles, with a projected resident population of about 14,800 persons, including an estimated seasonal resident population of about 2,600 persons. This represents an increase in the planned population from the 12,200 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Lake Geneva" sewer service area in the ensuing discussion.

5. Area E—This area consists of urban development along the north shoreline of Lake Como in the Town of Geneva. About 1,500 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.5 square miles, with a projected resident population of about 2,500 persons, including an estimated seasonal resident population of about 600 persons. This represents an increase in the planned population from the 1,900 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Lake Como" sewer service area in the ensuing discussion.

Table 158

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE LOWER FOX RIVER SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Population Served | Design Hydraulic Loading (mgd) |
| A | Mukwonago . . . . . . . . | 1.26 | 3,400 | 0.44 | 700 | 6,500 | 1.09 | 4.23 | 9,200 | 1.66 |
| B | East Troy . . . . . . . . . | 0.82 | 2,200 | 0.25 | 100 | 3,700 | 0.57 | 2.55 | 5,100 | 0.86 |
| C | Potter Lake . . . . . . . . | - - | - - | - - | 1,100[b] | 1,300[c] | 0.27 | 0.81 | 1,600[c] | 0.34 |
| D | Lake Geneva. . . . . . . . | 1.96 | 5,700 | 0.74 | 1,500[b] | 12,100[d] | 2.08 | 7.37 | 14,800[d] | 2.65 |
| E | Lake Como . . . . . . . . | - - | - - | - - | 1,500[b] | 2,300[e] | 0.44 | 1.50 | 2,500[e] | 0.53 |
| F | Lyons. . . . . . . . . . . . | - - | - - | - - | 500 | 600 | 0.13 | 0.30 | 700 | 0.15 |
| G | Genoa City. . . . . . . . . | 0.27 | 1,100 | 0.07 | - - | 1,400 | 0.13 | 0.88 | 1,800 | 0.22 |
| H | Wind Lake . . . . . . . . . | - - | - - | - - | 3,600[b] | 4,700[f] | 0.99 | 3.61 | 7,400[f] | 1.55 |
| I | Eagle Lake . . . . . . . . . | - - | - - | - - | 1,000[b] | 1,500[g] | 0.32 | 1.40 | 1,800[g] | 0.38 |
| J | Waterford-Rochester . . . | 0.94 | 3,400 | 0.24 | 100 | 5,000 | 0.58 | 2.64 | 5,300 | 0.64 |
| K | Tichigan Lake . . . . . . . | - - | - - | - - | 2,100[b] | 3,200[h] | 0.67 | 2.00 | 4,100[h] | 0.86 |
| L | Burlington . . . . . . . . . | 3.06 | 10,800 | 1.48 | 100 | 13,300 | 2.01 | 6.81 | 16,600 | 2.70 |
| M | Silver Lake. . . . . . . . . | 0.47 | 1,300 | 0.15 | - - | 1,900 | 0.28 | 1.03 | 2,400 | 0.38 |
| N | Twin Lakes . . . . . . . . | 2.31 | 3,400 | 0.41 | - - | 5,700[i] | 0.89 | 3.54 | 6,200[i] | 1.00 |
| O | Camp-Center Lakes. . . . | - - | - - | - - | 2,100[b] | 2,800[j] | 0.59 | 2.10 | 3,400[j] | 0.71 |
| P | Wilmot . . . . . . . . . . . | - - | - - | - - | 500 | 600 | 0.13 | 0.49 | 800 | 0.17 |
| Q | Cross Lake. . . . . . . . . | - - | - - | - - | 1,400[b] | 1,600[k] | 0.34 | 1.13 | 2,200[k] | 0.46 |
| R | Rock Lake. . . . . . . . . | - - | - - | - - | 600[b] | 800[l] | 0.17 | 0.68 | 1,300[l] | 0.27 |
| S | North Prairie. . . . . . . . | - - | - - | - - | 900 | 900 | 0.19 | 1.92 | 1,700 | 0.36 |
| | Total | 11.09 | 31,300 | 3.78 | 17,800 | 69,900 | 11.87 | 44.99 | 88,900 | 15.89 |

[a] *See Map 71.*

[b] *Does not include seasonal resident population on Potter Lake, Lake Geneva, Lake Como, Wind Lake, Eagle Lake, Tichigan Lake, Twin Lakes, Camp Lake, Cross Lake, and Rock Lake.*

[c] *Includes an estimated seasonal resident population of 200 persons.*

[d] *Includes an estimated seasonal resident popuation of 2,600 persons.*

[e] *Includes an estimated seasonal resident population of 600 persons.*

[f] *Includes an estimated seasonal resident population of 500 persons.*

[g] *Includes an estimated seasonal resident population of 400 persons.*

[h] *Includes an estimated seasonal resident population of 400 persons.*

[i] *Includes an estimated seasonal resident population of 1,400 persons.*

[j] *Includes an estimated seasonal resident population of 700 persons.*

[k] *Includes an estimated seasonal resident population of 100 persons.*

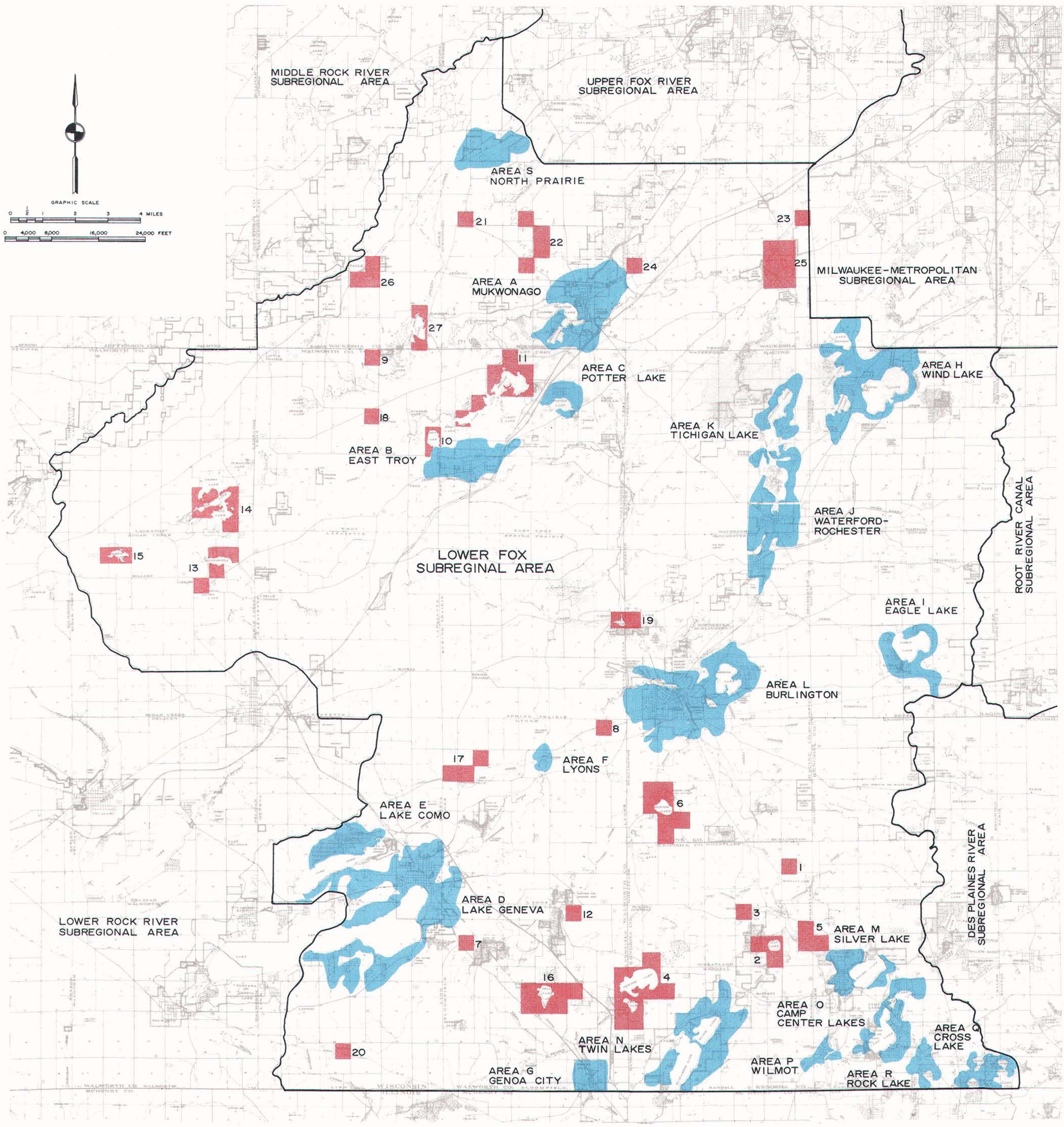
[l] *Includes an estimated seasonal resident population of 100 persons.*

*Source: SEWRPC.*

6. Area F—This area consists of the unincorporated village of Lyons in the Town of Lyons. About 500 persons resided in this area in 1975, but no centralized sanitary sewer service was provided. The Wisconsin Department of Natural Resources has ordered the installation of such service to the unincorporated village and, in response to this order, the Town of Lyons created a Sanitary District No. 2. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 0.3 square mile, with a projected resident population of about 700 persons. This represents no change from the forecast for the area for 1990 in the regional

## Map 71

### SEWER SERVICE ANALYSIS AREAS: LOWER FOX RIVER SUBREGIONAL AREA




LEGEND

SEWER SERVICE ANALYSIS AREAS

EXISTING URBAN DENSITY DEVELOPMENT OUTSIDE OF PROPOSED SEWER SERVICE ANALYSIS AREAS

7 CODE NUMBER FOR DEVELOPMENT OUTSIDE SEWER SERVICE AREA-- SEE TABLE 186

Urban development in the Lower Fox River watershed is concentrated in several relatively small cities and villages and unincorporated communities located along the shorelines of the many lakes which are found in this portion of the Region. For sewer service analysis purposes, 19 individual urban areas were identified, as shown on the above map. By the year 2000, about 88,900 persons are expected to reside in these 19 sewer service areas, which will approximate 45.0 square miles. In 1975 there were about 85,400 persons residing in the Lower Fox River subregional area, of which 31,300 were served by centralized sewer service and 54,100 by onsite sewage disposal systems.

*Source: SEWRPC.*

sanitary sewerage system plan. This subarea is referenced as the "Lyons" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Genoa City and environs. In 1975 sanitary sewer service was provided in this area to about 0.3 square mile, having a total resident population of about 1,100 persons. The total area anticipated to be served by the year 2000 approximates 0.9 square mile, with a projected resident population of about 1,800 persons. This represents the same planned population forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Genoa City" sewer service area in the ensuing discussion.

8. Area H—This area consists of urban development along the shorelines of Wind, Waubeesee, and Long Lakes in the Town of Norway and Lake Denoon in the City of Muskego. About 3,600 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The Town of Norway Sanitary District has been formed to provide centralized sanitary sewer service to that portion of the service area in Racine County. The total area anticipated to be served by the year 2000 approximates 3.6 square miles, with a projected resident population of about 7,400 persons, including an estimated seasonal resident population of about 500 persons. This represents an increase in the planned population from the 6,900 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Wind Lake" sewer service area in the ensuing discussion.

9. Area I—This area consists of urban development along the shoreline of Eagle Lake and in the unincorporated village of Kansasville in the Town of Dover. About 1,000 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The Town of Dover Sewer Utility District No. 1 has been formed to provide centralized sanitary sewer service to this concentration of urban development. The total area anticipated to be served by the year 2000 approximates 1.4 square miles, with a projected resident population of about 1,800 persons, including an estimated seasonal resident population of about 400 persons. This represents an increase in the planned population from the 1,600 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Eagle Lake" sewer service area in the ensuing discussion.

10. Area J—This area consists of the Villages of Rochester and Waterford and contiguous urban development in the Towns of Rochester and Waterford, and encompasses the entire service area of the Western Racine County Sewerage District. In 1975 sanitary sewer service was provided in this area to about 0.9 square mile, having a total resident population of about 3,400 persons. The total area anticipated to be served by the year 2000 approximates 2.6 square miles, with a projected resident population of about 5,300 persons. Due to revisions in the boundary between the Waterford-Rochester and Tichigan Lake sewer service areas, a direct comparison of population cannot be made with the regional sanitary sewerage system plan. This subarea is referenced as the "Waterford-Rochester" sewer service area in the ensuing discussion.

11. Area K—This area consists of urban development along the shoreline of Tichigan Lake in the Town of Waterford, including portions of the Town of Waterford Sanitary District No. 1. About 2,100 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The Tichigan Lake Sanitary District has been formed to provide such service. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 2.00 square miles, with a projected resident population of about 4,100 persons, including an estimated seasonal resident population of about 400 persons. Due to revisions in the boundary between Waterford-Rochester and Tichigan Lake sewer service areas, a direct comparison of population cannot be made with the regional sanitary sewerage system plan. This subarea is referenced as the "Tichigan Lake" sewer service area in the ensuing discussion.

12. Area L—This area consists of the City of Burlington and environs, including urban development along the shoreline of Browns Lake in the Town of Burlington. In 1975 sanitary sewer service was provided in this area to about 3.1 square miles, having a total resident population of about 10,800 persons. The total area anticipated to be served by the year 2000 approximates 6.81 square miles, with a projected resident population of about 16,600 persons. This represents an increase in the planned population from the 15,000 forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Burlington" sewer service area in the ensuing discussion.

13. Area M—This area consists of the Village of Silver Lake and environs. In 1975 sanitary sewer service was provided in this area to about 0.5 square mile, having a total resident population of about 1,300 persons. The total area anticipated to be served by the year 2000 approximates 1.0 square mile, with a projected resident population of about 2,400 persons. This represents a decrease in the planned population from the 3,300 persons forecast for the area for 1990 in the regional

sanitary sewerage system plan. This subarea is referenced as the "'Silver Lake" sewer service area in the ensuing discussion.

14. Area N—This area consists of the Village of Twin Lakes and environs. In 1975 sanitary sewer service was provided in this area to about 2.3 square miles, having a total resident population of about 3,400 persons. The total area anticipated to be served by the year 2000 approximates 3.5 square miles, with a projected resident population of about 6,200 persons, including an estimated seasonal resident population of about 1,400 persons. This represents an increase in the planned population from the 4,200 forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Twin Lakes" sewer service area in the ensuing discussion.

15. Area O—This area consists of urban development along the shorelines of Camp and Center Lakes in the Town of Salem. About 2,100 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 2.1 square miles, with a projected resident population of about 3,400 persons, including an estimated seasonal population of about 700 persons. This represents an increase in the planned population from the 2,400 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Camp-Center Lakes" sewer service area in the ensuing discussion.

16. Area P—This area consists of the unincorporated village of Wilmot in the Town of Salem. About 500 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 0.5 square mile, with a projected resident population of about 800 persons. This represents an increase in the planned population from the 600 forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Wilmot" sewer service area in the ensuing discussion.

17. Area Q—This area consists of urban development along the shorelines of Cross, Voltz, Benet, and Shangrila Lakes in the Towns of Salem and Bristol. About 1,400 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.1 square mile, with a projected resident population of about 2,200 persons, including an estimated seasonal resident population of about 100 persons. This represents an increase in the planned population from the 1,200 forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Cross Lake" sewer service area in the ensuing discussion.

18. Area R—This area consists of urban development along the shoreline of Rock Lake and in the unincorporated village of Trevor in the Town of Salem. About 600 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 0.7 square mile, with a projected resident population of about 1,300 persons, including an estimated seasonal resident population of about 100 persons. This represents an increase in the planned population from the 700 forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Rock Lake" sewer service area in the ensuing discussion.

19. Area S—This area consists of the Village of North Prairie and environs. About 900 persons resided in this area in 1975, but no centralized sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.9 square miles, with a projected resident population of about 1,700 persons. This area was not planned to be sewered in the regional sanitary sewerage system plan. This subarea is referenced as the "North Prairie" sewer service area in the ensuing discussion.

Summary of Previously Prepared Regional Plan Elements

The Fox River watershed plan,[29] as adopted in June 1970 by the Regional Planning Commission, contained specific recommendations pertaining to sewerage system development and stream water quality management for the Lower Fox River subregional area. These recommendations were developed from a detailed examination of seven basic alternative stream water quality management plan elements for the entire watershed.

Following the preparation and adoption of the Fox River watershed plan, several developments occurred which necessitated a reevaluation of the recommendations in the adopted Fox River watershed plan prior to their integration into the regional sanitary sewerage system plan. These developments resulted in an amendment to the Fox River watershed plan, which included a revised number of recommended treatment facilities to ulti-

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[29] *SEWRPC Planning Report No. 12, A Comprehensive Plan for the Fox River Watershed.*

mately serve the existing and anticipated urban development in the upper Fox River watershed and revisions concerning the type of treatment units recommended.[30] Because of the extensive consideration of alternative sanitary sewerage system plans under the Fox River watershed study, the procedure for evaluating alternative plans normally utilized in the development of the regional sanitary sewerage system plan was not utilized, and only a recommended plan was presented. This plan consisted of the basic stream water quality management recommendations included in the adopted Fox River watershed plan, modified to reflect the results of the reevaluation under the regional sanitary sewerage system planning program.

Formulation of Alternatives

Several local planning efforts have taken place which represent steps toward the implementation of the Lower Fox River watershed water quality management recommendations of the Fox River watershed plan and the regional sanitary sewerage system plan. Local facility planning has been completed or is nearing completion for the Mukwonago, East Troy, Potter Lake, Lake Geneva, Lake Como, Wind Lake, Eagle Lake, Camp and Center Lakes, Wilmot, Cross Lake, and Rock Lake sewer service areas. Facility planning is also underway for the Lyons, Twin Lakes, Waterford-Rochester, and Tichigan Lake sewer service areas. With regard to the number and location of public wastewater treatment facilities, these local planning efforts, which have been completed or are nearing completion, have verified the recommendations of the regional sanitary sewerage system plan.

In view of these developments, it was concluded that the recommendations of the regional sanitary sewerage system plan with regard to the number and location of the public treatment facilities in the Lower Fox River subregional area should be incorporated into the areawide water quality management plan without further alternative consideration. Thus, with regard to the number and location of wastewater treatment plants, only the recommended plan for the Lower Fox River subregional area as developed under the regional sanitary sewerage system plan is described herein, with certain modifications indicated as desirable by subsequent system and facilities planning efforts. Alternatives are evaluated with regard to the type of treatment system to be utilized. One major recommendation of the areawide water quality management planning program, in addition to the regional sanitary sewerage system plan recommendations, is the addition of the North Prairie subarea to the areas recommended for sewer service. Local planning for the North Prairie area had been completed in 1971. Sewer service has also been recommended for the area in the adopted regional land use plan coincident with a change in population from 800 persons in 1975 to 1,700 persons in the year 2000. The North Prairie subarea is somewhat isolated from other sewer service areas in the Region, the closest being the Wales sewer service area in the Middle Rock River subregional area—over four miles away. In view of this, no specific alternative analyses were conducted with regard to sewer system interconnection for the North Prairie sewer service area.

Results of water quality simulations are presented under the previous section on the diffuse source control element recommendations for the Fox River watershed. Sanitary sewerage system plans for the 19 sewer service areas that lie within the Lower Fox River subregional area are described in the following sections.

Proposed Plan—Mukwonago Subarea

In 1975 the wastewater treatment facility serving the Mukwonago sewer service area had an average hydraulic design capacity of 0.22 mgd and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Mukwonago sewer service area of about 1.09 mgd in 1985 and about 1.66 mgd in the year 2000. This year 2000 design flow is somewhat larger than the estimated 1990 design flow of 1.40 mgd anticipated under the regional sanitary sewerage system plan.

In 1977 the Village of Mukwonago had completed facilities planning for construction of a new wastewater treatment facility downstream of the existing facility with a force main discharge to the Fox River. The proposed wastewater treatment plant is designed to provide secondary waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. The plant is proposed to have an average hydraulic design capacity of about 1.5 mgd.

In order to meet established water use objectives for the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for disinfection prior to discharge to the Fox River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan. That plan recommended the provision of secondary waste treatment plus conventional advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for effluent disinfection. The treatment levels recommended in the regional sanitary sewerage system plan, however, were based upon the assumption that plant effluent would continue to be discharged to the Mukwonago River. The construction of the outfall to

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[30] *For a detailed discussion of the developments affecting the Fox River watershed recommendations and the alternative analyses which were reevaluated, as well as the amendments made to the adopted watershed plan, see Chapter XI of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.*

the Fox River, with the corresponding elimination of the need to provide advanced waste treatment for nitrification, is considered to be consistent with the recommendations of the regional sanitary sewerage system plan.

As previously noted, the local facilities planning work has been completed for the Village of Mukwonago wastewater treatment plant, and the detailed design work is to be started in 1978. Because of this existing stage of implementation, the decision to provide advanced waste treatment followed by discharge to the surface waters has been treated as a committed local decision, even though the areawide analysis indicates that, on a generalized basis, an effluent land application alternative may be less costly than providing the levels of treatment needed prior to discharge to the surface waters. The proposed facilities should be designed to allow for expansion to ultimately accommodate the facilities needed to reduce the total phosphorus concentration in the effluent to about 0.1 mg/l. Future facilities planning efforts designed to evaluate the phosphorus reduction component of the proposed plan should further consider the land application alternative. The recommended performance standards for the Mukwonago wastewater treatment plant are set forth in Table 159, and the proposal is shown on Map 72.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Mukwonago sewer service area is about $6,990,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $4,117,000, with an estimated average annual operation and maintenance cost of $253,200 (see Table 160).

Proposed Plan—East Troy and Potter Lake Subareas

In 1975 the wastewater treatment facility serving the East Troy sewer service area had an average hydraulic design capacity of 0.32 mgd and provided a secondary level of waste treatment. It is anticipated that future growth and connection of the Potter Lake sewer service area will require an average hydraulic design capacity for the East Troy sewer service area of about 0.84 mgd in 1985 and about 1.20 mgd in the year 2000. This year 2000 design flow is somewhat larger than the estimated 1990 design flow of 0.93 mgd anticipated under the regional sanitary sewerage system plan.

During 1978 the Village of East Troy was conducting preliminary facilities planning for construction of a new treatment plant. The facility plan is evaluating both effluent land application and treatment and discharge alternatives. The plan proposes that the new treatment plant have an average hydraulic design capacity of about 0.70 mgd.

In order to meet established water use objectives for the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Honey Creek. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should

Table 159

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MUKWONAGO SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Mukwonago | 1.09 | 1.66 | Mukwonago | 6,500 | 9,200 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Fecal Coliform Concentration: 200/100 ml |

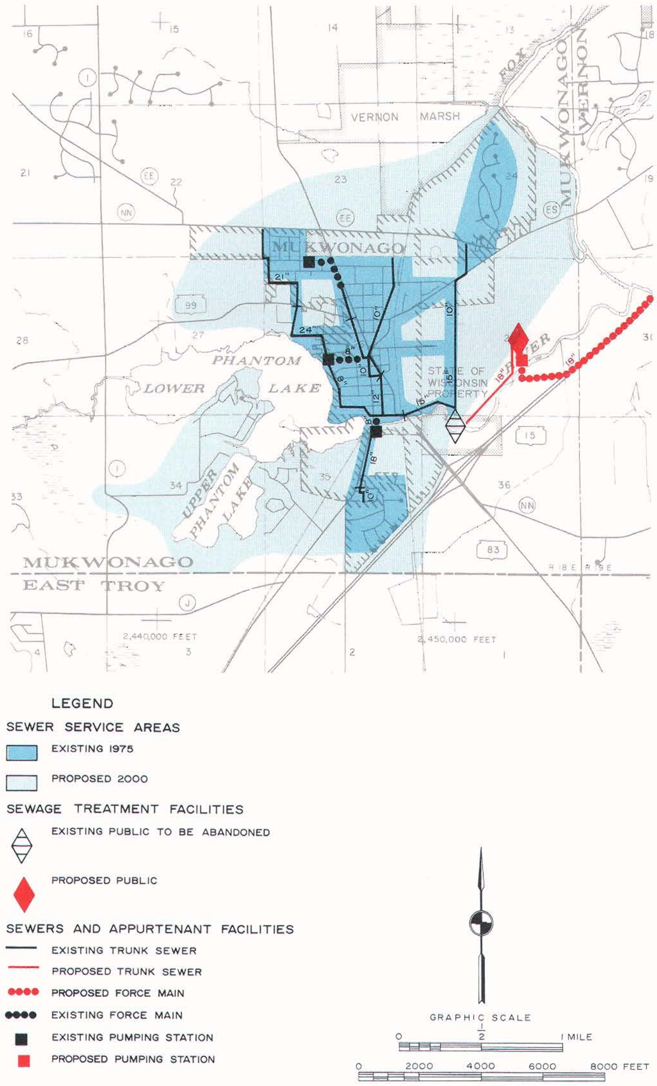
[a] *See Map 71.*

[b] *This treatment standard differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent disinfection. The recommendations of the regional sanitary sewerage system plan were based upon the discharge of plant effluent to the Mukwonago River.*

*Source: SEWRPC.*

Map 72

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MUKWONAGO SEWER SERVICE AREA—LOWER FOX RIVER SUBREGIONAL AREA: 2000**




The areawide water quality management plan proposes that the Mukwonago wastewater treatment plant be relocated to a new site downstream of the existing site facility and that an outfall sewer be constructed to convey the plant effluent to the main stem of the Fox River. In order to meet the established water use objectives for the Fox River, it is proposed that the Mukwonago facility provide secondary waste treatment with a high level of advanced waste treatment for phosphorus removal—producing an effluent concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River. Completed local plans recommended the provision of conventional advanced waste treatment for phosphorus removal—producing an effluent concentration of 1.0 mg/l. Future planning efforts should evaluate effluent land application as an alternative to increasing the level of phosphorus removal. The proposed plan also includes a trunk sewer to convey waste from the existing to the proposed treatment plant site.

*Source: SEWRPC.*

be achieved. That plan recommended that the East Troy plant effluent have a total phosphorus concentration of 1.0 mg.l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

Based upon the general analyses described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and effluent land application is considered to be a viable alternative to providing secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for plants the size of the East Troy facility. Thus, the proposed areawide water quality management plan for the East Troy and Potter Lake areas is based upon the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. The recommended performance standards for the East Troy wastewater treatment plant are set forth in Table 161, and the proposal is shown on Map 73.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the East Troy and Potter Lake sewer service areas is about $6,009,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $5,050,000, with an estimated average annual operation and maintenance cost of $148,000 (see Table 162).

## Alternative Plans—Lake Geneva and Lake Como Subareas

In 1975 the wastewater treatment facility serving the Lake Geneva sewer service area had an average hydraulic design capacity of 1.10 mgd, and provided a secondary level of waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth and connection of the Lake Como sewer service area will require an average hydraulic design capacity for the combined Lake Geneva and Lake Como sewer service areas of about 2.52 mgd in 1985 and about 3.18 mgd in the year 2000. This year 2000 design flow is greater than the estimated 1990 design flow of 2.70 mgd anticipated under the regional sanitary sewerage system plan.

As previously noted, in 1978 the City of Lake Geneva, in conjunction with other communities in the Lake Geneva area, had completed local facilities planning to determine existing and future wastewater treatment and conveyance needs for the sewer service areas around Lake Geneva and Lake Como. The local facility planning study recommended that the Lake Geneva wastewater

Table 160

DETAILED ECONOMIC ANALYSIS COST ESTIMATES–PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE MUKWONAGO SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Mukwonago . . . . | $3,982,000 | $253,000 | $3,011,000 | $3,891,000 | $6,902,000 | $191,000 | $247,000 | $438,000 |
| Trunk Sewers Village of Mukwonago . . . . | 135,000 | 200 | 85,000 | 3,000 | 88,000 | 5,400 | 200 | 5,600 |
| Total | $4,117,000 | $253,200 | $3,096,000 | $3,894,000 | $6,990,000 | $196,400 | $247,200 | $443,600 |

*Source: SEWRPC.*

Table 161

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS–PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAST TROY AND POTTER LAKE SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of East Troy | 0.84 | 1.20 | East Troy and Potter Lake | 5,000 | 6,700 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with conventional advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection.*

*Source: SEWRPC.*

Table 162

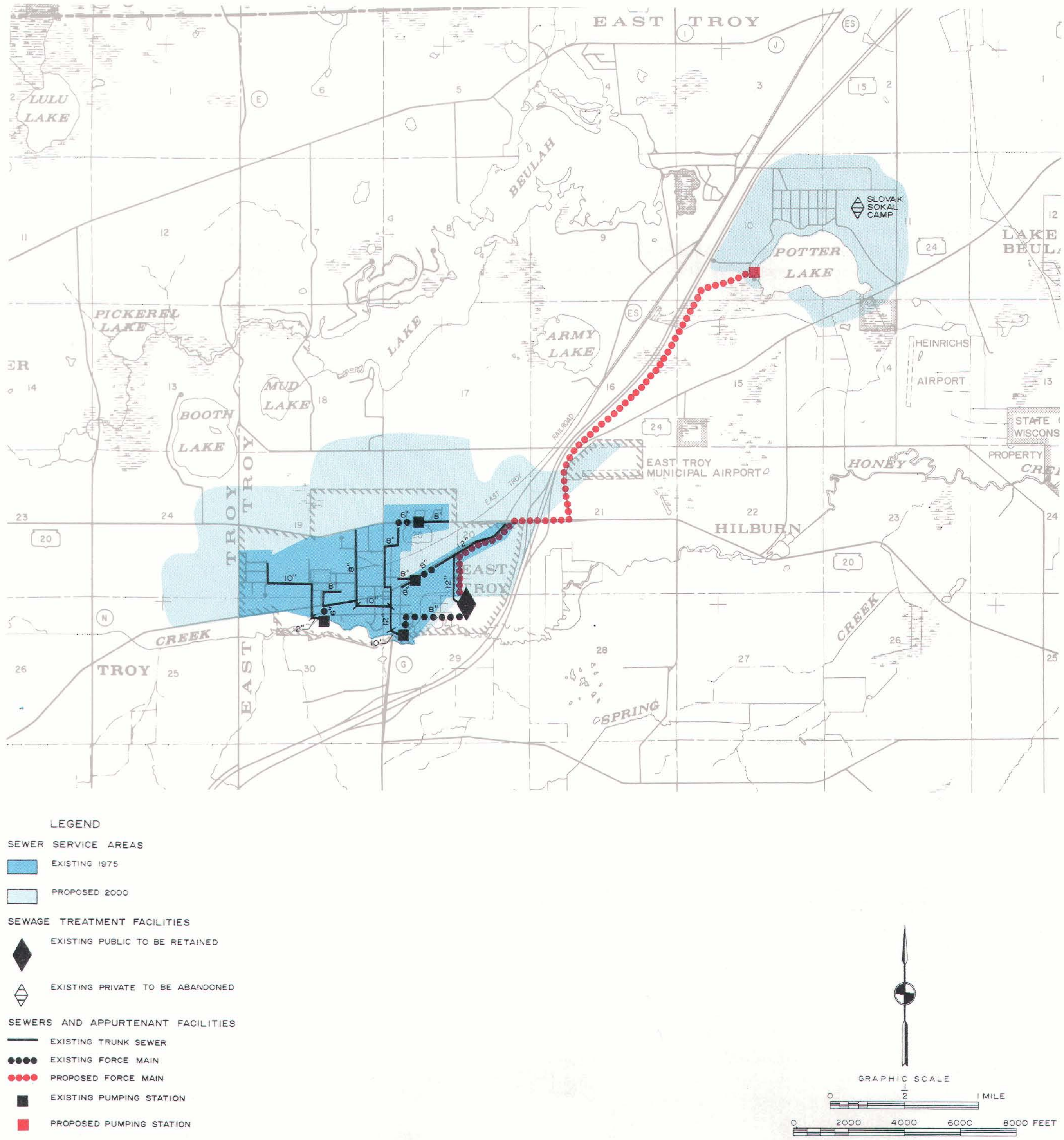
DETAILED ECONOMIC ANALYSIS COST ESTIMATES–PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAST TROY AND POTTER LAKE SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of East Troy | | | | | | | | |
| Facilities. . . . . . . . . . . | $3,963,000 | $142,000 | $3,069,000 | $2,203,000 | $5,272,000 | $195,000 | $140,000 | $335,000 |
| Land . . . . . . . . . . . . . | 396,000 | - - | 227,000 | - - | 227,000 | 14,000 | - - | 14,000 |
| Subtotal | $4,359,000 | $142,000 | $3,296,000 | $2,203,000 | $5,499,000 | $209,000 | $140,000 | $349,000 |
| Trunk Sewer Potter Lake-East Troy . . . . | 691,000 | 6,000 | 434,000 | 76,000 | 510,000 | 28,000 | 5,000 | 33,000 |
| Total | $5,050,000 | $148,000 | $3,730,000 | $2,279,000 | $6,009,000 | $237,000 | $145,000 | $382,000 |

*Source: SEWRPC.*

Map 73

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAST TROY AND POTTER LAKE SEWER SERVICE AREAS—LOWER FOX RIVER SUBREGIONAL AREA: 2000




In order to resolve existing problems due to malfunctioning septic tank systems, it is proposed that a sewerage system be constructed to serve the urban development along Potter Lake, with treatment for the wastewater being provided by an expanded and upgraded existing East Troy wastewater treatment plant. In order to meet the established water use objectives for Honey Creek, the East Troy plant will need to provide either land application of plant effluent following the current secondary level of treatment or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Honey Creek. Wastewater would be conveyed from the Potter Lake sewer service area to the East Troy treatment plant via a trunk sewer system as indicated on the above map.

*Source: SEWRPC.*

treatment plant be expanded and upgraded to serve the Lake Geneva and Lake Como areas. The local facility plan further recommended, after consideration of several alternatives, that the Villages of Williams Bay and Fontana, together with adjacent urban development along the north and south shorelines of Lake Geneva, be served through the proposed new Village of Walworth treatment facility. The local facilities plan recommended one revision in the sewer service area boundary delineation included in the regional sanitary sewerage system plan. The local facilities plan proposes that sanitary sewer service be extended from the Lake Geneva wastewater treatment plant along the southern shoreline of Lake Como to the Interlaken resort area at the western end of the lake, thus permitting the abandonment of the existing Interlaken resort wastewater treatment plant. In the regional sanitary sewerage system plan, this abandonment was recommended to be effected through a sewer service extension from the Village of Williams Bay. The sewer service area delineations included herein have been refined to reflect the minor adjustment in the sewer service area recommended in the local facility plan.

In view of the findings of the local facility plan, no further alternative analyses have been conducted with regard to the number and location of the treatment facilities for the sewer service areas around Lake Geneva and Lake Como. With regard to the treatment facilities serving the sewer service areas in the Lower Fox River subregional area, it is recommended that the Lake Geneva plant be expanded to service the Lake Geneva and Lake Como sewer service areas.

In order to meet established water use objectives for the White River and the Fox River, the Lake Geneva facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the White River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to level of phosphorus removal which should be achieved. That plan recommended that the Lake Geneva plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the general analysis described earlier in this chapter, the effluent land application and treatment and discharge alternatives should be considered further for a plant the size of the Lake Geneva facility. Accordingly, two treatment alternatives were considered for the Lake Geneva and Lake Como sewer service areas. The first alternative would provide for continued discharge of the Lake Geneva wastewater treatment plant effluent to the White River following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the provision of a land application system for disposal of treatment plant effluent from the Lake Geneva wastewater treatment facility.

The recommended wastewater treatment plant performance standards for both of the alternatives are set forth in Table 163, and the two proposals are shown on Map 74.

Alternative Plan 1 is based upon the provision of secondary waste treatment with advanced waste treatment for ammonia-nitrogen and phosphorus removal utilizing conventional chemical treatment for phosphorus removal, biological secondary treatment and nitrification, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to the White River. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Lake Geneva and Lake Como sewer service areas is about $13,323,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $9,953,000, with an estimated average annual operation and maintenance cost of $430,000 (see Table 164).

Alternative Plan 2 is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural land in the Town of Linn was selected to receive the effluent from the Lake Geneva wastewater treatment facility. This site would require that the effluent be pumped about 24,000 feet. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Lake Geneva and Lake Como sewer service areas is about $15,286,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $15,064,000, with an estimated average annual operation and maintenance cost of $299,400 (see Table 164).

On an equivalent annual cost basis, including the cost of sludge-related facilities required under Alternative Plan 1, Alternative Plan 1 would be about 3 percent less costly to implement than would Alternative Plan 2. The cost of the two alternatives are about equal—well within the accuracy of the cost estimating procedures. However, there are other less tangible, but nevertheless real, factors which should be considered. Alternative Plan 1 could be more readily implemented, since this alternative represents a continuation of existing practices, with the added construction and operational requirements associated with the recommended expansion and upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus

Table 163

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE LAKE GENEVA AND LAKE COMO SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Lake Geneva | 2.52 | 3.18 | Lake Geneva, Lake Como | 14,400 | 17,300 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Effluent Aeration<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of Lake Geneva | 2.52 | 3.18 | Lake Geneva, Lake Como | 14,400 | 17,300 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the White River.*

*Source: SEWRPC.*

this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 880 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management. Alternative Plan 2 also requires the construction of a major conveyance system to transport the treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1.

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from the wastewater back to the agricultural land, and the treatment plant discharge of pollutant would be completely eliminated from the surface waters. Based upon the above considerations, neither alternative is clearly better. However, the areawide water quality management plan is based upon the land application alternative, but recognizes the need for more detailed local facilities planning to examine alternatives providing for surface water discharge of plant effluent as well as the land application alternative.

Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to the White River should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l.

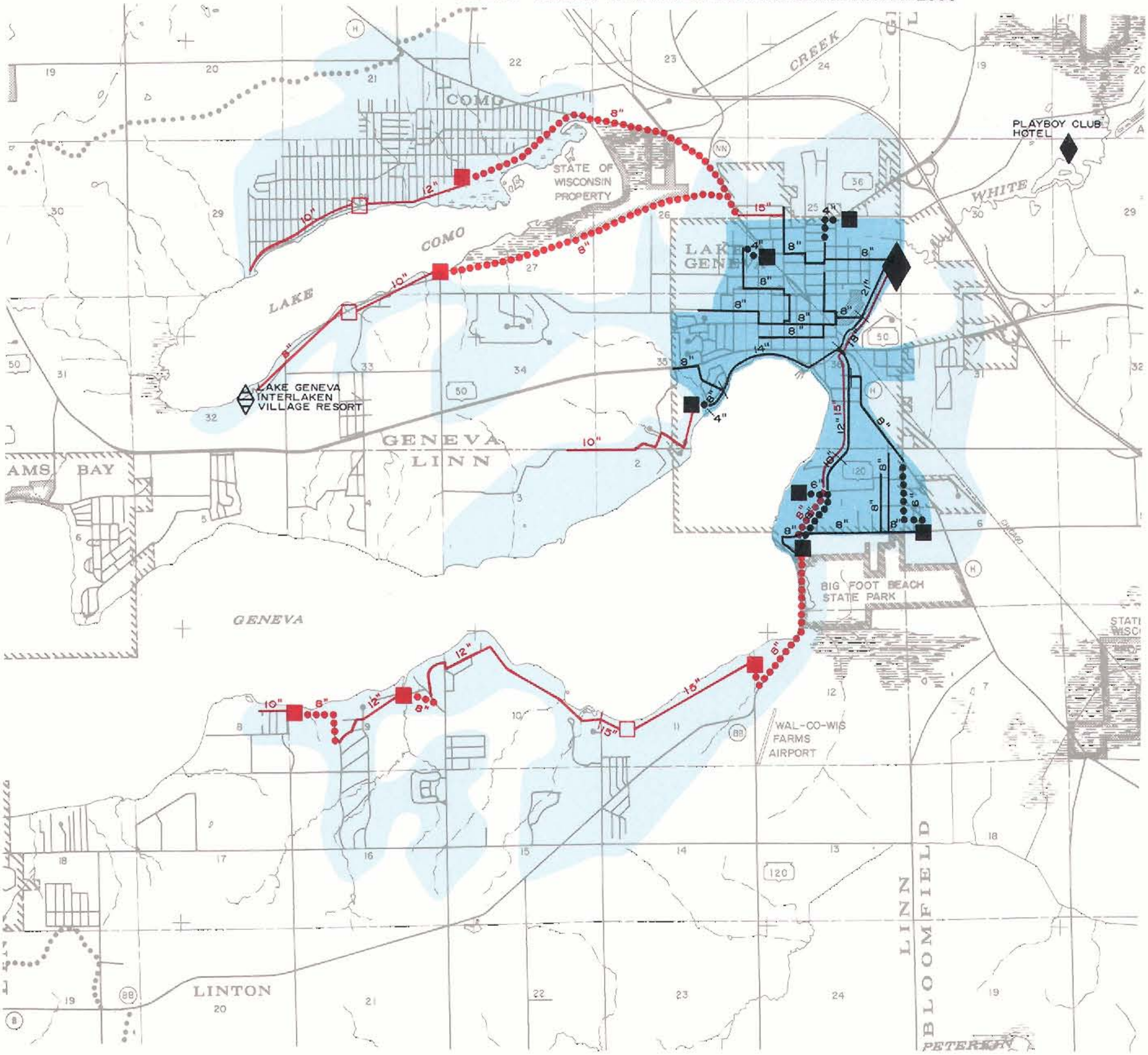
Proposed Plan—Lyons Subarea

No sanitary sewer service is currently being provided in the Lyons subarea. The areawide water quality management plan proposes a new sanitary sewerage system for the Lyons subarea. It is anticipated that an average hydraulic design capacity for the Lyons sewer service area will be about 0.13 mgd in 1985 and about 0.15 mgd in the year 2000. This year 2000 design flow is the same as the estimated 1990 design flow anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the White River, this facility will need to provide either a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary

Map 74

## ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE LAKE GENEVA AND LAKE COMO SEWER SERVICE AREAS—LOWER FOX RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

EXISTING PRIVATE TO BE RETAINED

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

PROPOSED TRUNK SEWER

EXISTING FORCE MAIN

PROPOSED FORCE MAIN

PROPOSED LIFT STATION

EXISTING PUMPING STATION

PROPOSED PUMPING STATION

GRAPHIC SCALE

0 ½ 1 MILE

0 2000 4000 6000 8000 FEET

The areawide water quality management plan proposes that the existing Lake Geneva treatment plant be expanded to meet the anticipated year 2000 needs of the Lake Geneva sewer service area, and the addition of wastewater from the Lake Como sewer service area. In order to meet the established water use objectives for the White River, it will be necessary for the Lake Geneva plant to be upgraded to provide either land application of plant effluent following a secondary level of treatment, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent concentration of 0.1 mg/l total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the White River. Trunk sewers are proposed to serve the north and south shores of Lake Geneva in the Towns of Geneva and Linn and to serve the Lake Como sewer service area. The analyses indicated that land application of plant effluent is a viable alternative to treatment and discharge to the surface waters.

*Source: SEWRPC.*

Table 164

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE LAKE GENEVA AND LAKE COMO SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant City of Lake Geneva . . . . . . . | $ 4,799,000 | $397,000 | $ 3,629,000 | $6,024,000 | $9,653,000 | $230,000 | $382,000 | $612,000 |
| Trunk Sewers | | | | | | | | |
| Lake Como—North . . . . . . . . | $1,037,000 | 8,000 | 651,000 | 105,000 | 756,000 | 41,000 | 7,000 | 48,000 |
| Lake Como—South . . . . . . . . | 1,295,000 | 9,000 | 812,000 | 115,000 | 927,000 | 52,000 | 7,000 | 59,000 |
| Lake Geneva—North . . . . . . . | 336,000 | 400 | 211,000 | 6,000 | 217,000 | 13,000 | 400 | 13,400 |
| Lake Geneva—South . . . . . . . | 2,486,000 | 16,000 | 1,560,000 | 210,000 | 1,770,000 | 99,000 | 13,000 | 112,000 |
| Trunk Subtotal | $ 5,154,000 | $ 33,400 | $ 3,234,000 | $ 436,000 | $ 3,670,000 | $205,000 | $ 27,400 | $232,400 |
| Total | $ 9,953,000 | $430,400 | $ 6,863,000 | $6,460,000 | $13,323,000 | $435,000 | $409,400 | $844,400 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant City of Lake Geneva | | | | | | | | |
| Facilities. . . . . . . . . . . . . | $ 9,118,000 | $266,000 | $ 7,040,000 | $4,122,000 | $11,162,000 | $446,000 | $261,000 | $707,000 |
| Land . . . . . . . . . . . . . . . | 792,000 | - - | 454,000 | - - | 454,000 | 29,000 | - - | 29,000 |
| Subtotal | $ 9,910,000 | $266,000 | $ 7,494,000 | $4,122,000 | $11,616,000 | $475,000 | $261,000 | $736,000 |
| Trunk Sewers | | | | | | | | |
| Lake Como—North . . . . . . . . | 1,037,000 | 8,000 | 651,000 | 105,000 | 756,000 | 41,000 | 7,000 | 48,000 |
| Lake Como—South . . . . . . . . | 1,295,000 | 9,000 | 812,000 | 115,000 | 927,000 | 52,000 | 7,000 | 59,000 |
| Lake Geneva—North . . . . . . . | 336,000 | 400 | 211,000 | 6,000 | 217,000 | 13,000 | 400 | 13,400 |
| Lake Geneva—South . . . . . . . | 2,486,000 | 16,000 | 1,560,000 | 210,000 | 1,770,000 | 99,000 | 13,000 | 112,000 |
| Trunk Subtotal | $ 5,154,000 | $ 33,400 | $ 3,234,000 | $ 436,000 | $ 3,670,000 | $205,000 | $ 27,400 | $232,400 |
| Total | $15,064,000 | $299,400 | $10,728,000 | $4,558,000 | $15,286,000 | $680,000 | $288,400 | $968,400 |

[a] *This alternative does not include the cost of additional facilities related to the increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the additional sludge-handling and -disposal requirement is $1,545,000. The estimated capital cost for construction of the added sludge-related facilities is $1,283,000, with an estimated average annual operation and maintenance cost of $40,000 over the design period 1975-2000.*

*Source: SEWRPC.*

waste treatment for effluent disinfection prior to discharge to the White River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the provision of advanced waste treatment for phosphorus removal. That plan recommended the provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and effluent land application is considered to be a viable alternative to providing secondary waste treatment with conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection for plants the size of the Lyons facility. The recommendation of the areawide water quality management planning program is based on the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to the White River should be considered. The recommended performance standards for the Lyons wastewater treatment plant are set forth in Table 165, and the proposal is shown on Map 75.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Lyons sewer service area is about

$1,792,000. The estimated capital cost for constructing the necessary treatment facilities is $1,468,000, with an estimated average annual operation and maintenance cost of $48,000 (see Table 166).

Proposed Plan—Genoa City Subarea

In 1975 the wastewater treatment facility serving the Genoa City sewer service area had an average hydraulic design capacity of 0.20 mgd, and provided a secondary level of waste treatment and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Genoa City sewer service area of about 0.13 mgd in 1985 and about 0.22 mgd in the year 2000. This year 2000 design flow is smaller than the estimated 1990 design flow of 0.30 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for Nippersink Creek and the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for disinfection. The recommendations concerning treatment and discharge to surface waters differ from the recommendations contained in the regional sanitary sewerage system plan only with regard to the provision of advanced waste treatment for phosphorus removal. That plan recommended the provision of secondary waste treatment and auxiliary waste treatment for effluent disinfection.

Table 165

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE LYONS SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Lyons | 0.13 | 0.15 | Lyons | 600 | 700 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 mg/l<br>- - |

[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection prior to discharge to the White River.*

*Source: SEWRPC.*

Table 166

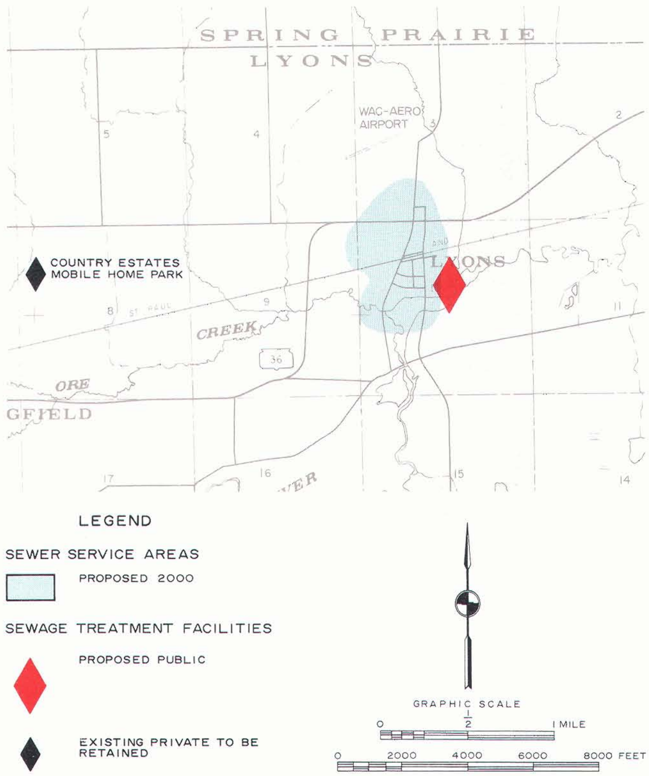
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE LYONS SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Town of Lyons Sanitary District No. 1 | | | | | | | | |
| Facilities. . . . . . . . . . . | $1,401,000 | $48,000 | $1,072,000 | $682,000 | $1,754,000 | $68,000 | $43,000 | $111,000 |
| Land . . . . . . . . . . . . . | 67,000 | - - | 38,000 | - - | 38,000 | 2,000 | - - | 2,000 |
| Subtotal | $1,468,000 | $48,000 | $1,110,000 | $682,000 | $1,792,000 | $70,000 | $43,000 | $113,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $1,468,000 | $48,000 | $1,110,000 | $682,000 | $1,792,000 | $70,000 | $43,000 | $113,000 |

*Source: SEWRPC.*

Map 75

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE LYONS SEWER SERVICE AREA– LOWER FOX RIVER SUBREGIONAL AREA: 2000**




In response to a Wisconsin Department of Natural Resources order to provide centralized sanitary sewer service to urban development comprising the unincorporated village of Lyons, the Town of Lyons has formed a sanitary district and has completed preliminary engineering studies for establishing the necessary system. Accordingly, the areawide water quality management plan proposes that the Lyons wastewater treatment plant be designed to meet the anticipated year 2000 needs. In order to meet the established water use objectives for the White River, it will be necessary for the plant to provide either land application of plant effluent following a secondary level of treatment, or secondary waste treatment, conventional advanced waste treatment for phosphorus removal, and auxiliary waste treatment for disinfection prior to discharge to the White River.

*Source: SEWRPC.*

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application is considered to be a viable alternative to providing secondary waste treatment followed by a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment for treatment plants the size of the Genoa City facility. Thus, the areawide water quality management plan is based upon the effluent land application alternative but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l. The recommended performance standards for the Genoa City wastewater treatment plant are set forth in Table 167, and the proposal is shown on Map 76.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Genoa City sewer service area is about $2,130,000. The estimated capital cost for constructing the necessary additional treatment facilities is $1,673,000, with an estimated average annual operation and maintenance cost of $56,000 (see Table 168).

Proposed Plan—Wind Lake Subarea

In 1978 construction of a new wastewater treatment facility for the Town of Norway Sanitary District No. 1 was completed. The plant is designed with an average hydraulic capacity of 0.75 mgd to provide secondary and tertiary waste treatment, advanced waste treatment for nitrification and phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Waubeesee Lake drainage canal. The planned sewer service area includes the existing urban development around Wind Lake, as recommended in the Fox River watershed study, as well as the urban development around the nearby Waubeesee, Long, and Denoon Lakes as recommended in the regional sanitary sewerage system plan and in engineering studies completed for the District. It is anticipated that existing development and future growth will require an average hydraulic design capacity for the Wind Lake sewer service area of about 0.99 mgd in 1985 and about 1.55 mgd in the year 2000. This year 2000 design flow is about the same as the estimated 1990 design flow of 1.50 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the Wind Lake Drainage Canal and the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Waubeesee Lake drainage canal. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal. That plan recommended that the Town of Norway Sanitary District No. 1 plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

Table 167

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GENOA CITY SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Genoa City | 0.13 | 0.22 | Genoa City | 1,400 | 1,800 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 mg/l<br>- - |

[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection prior to discharge to Nippersink Creek.*

*Source: SEWRPC.*

Table 168

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GENOA CITY SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Genoa City | | | | | | | | |
| Facilities. . . . . . . . . . . | $1,576,000 | $56,000 | $1,209,000 | $865,000 | $2,074,000 | $76,000 | $55,000 | $131,000 |
| Land . . . . . . . . . . . . . | 97,000 | - - | 56,000 | - - | 56,000 | 4,000 | - - | 4,000 |
| Subtotal | $1,673,000 | $56,000 | $1,265,000 | $865,000 | $2,130,000 | $80,000 | $55,000 | $135,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $1,673,000 | $56,000 | $1,265,000 | $865,000 | $2,130,000 | $80,000 | $55,000 | $135,000 |

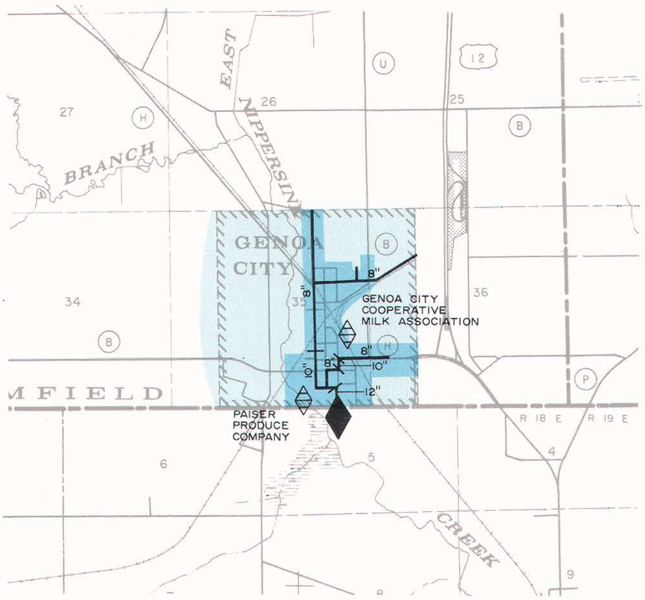
*Source: SEWRPC.*

As previously noted, the new Town of Norway Sanitary District No. 1 wastewater treatment facility was completed in 1978. The new facility provides for secondary waste treatment with advanced waste treatment for nitrification and phosphorus removal, tertiary treatment, and auxiliary waste treatment for effluent aeration and disinfection. This new facility represents a major step toward the implementation of the treatment and discharge alternative. In view of the existing stage of implementation, the decision to provide advanced waste treatment followed by discharge to surface waters has been treated as a committed local decision, even though the areawide analysis indicates that, on a generalized basis, the land application alternative may be less costly than providing the levels of treatment needed prior to discharge to surface waters. Future facilities planning efforts designed to evaluate the phosphorus reduction component of the recommendations should further consider the land application alternative. The recommended performance standards for the Wind Lake wastewater treatment plant are set forth in Table 169, and the proposal is shown on Map 77.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Wind Lake sewer service area is about $6,849,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $5,003,000, with an estimated average annual operation and maintenance cost of $215,000 (see Table 170).

## Map 76

### PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE GENOA CITY SEWER SERVICE AREA— LOWER FOX RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

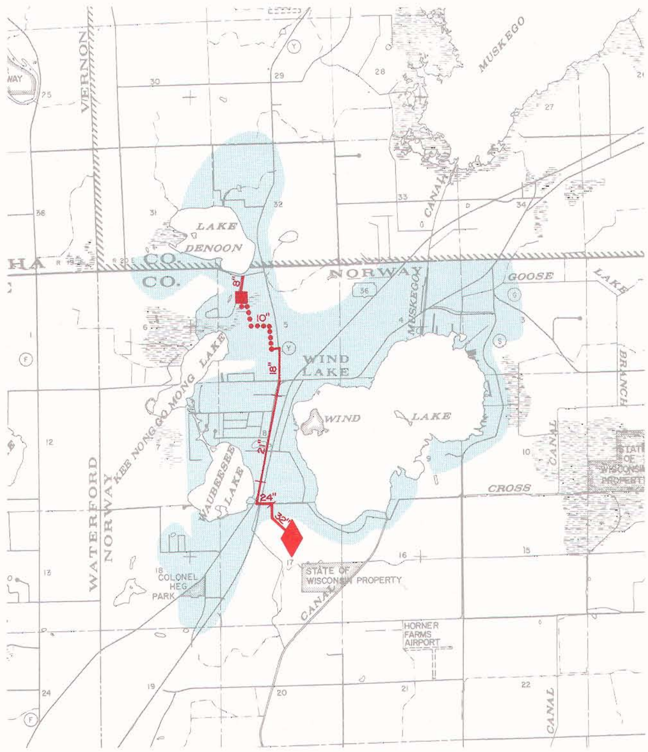
GRAPHIC SCALE 0 ½ 1 MILE; 0 2000 4000 6000 FEET

The areawide water quality management plan proposes that the existing Genoa City wastewater treatment plant be expanded and upgraded to meet anticipated year 2000 needs. In order to meet the established water use objectives for Nippersink Creek, it will be necessary for the plant to provide either land application of plant effluent following the current secondary level of treatments or secondary waste treatment with a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to Nippersink Creek.

*Source: SEWRPC.*

## Map 77

### PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WIND LAKE SEWER SERVICE AREA— LOWER FOX RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

PROPOSED PUBLIC

SEWERS AND APPURTENANT FACILITIES

PROPOSED TRUNK SEWER

PROPOSED FORCE MAIN

PROPOSED PUMPING STATION

GRAPHIC SCALE 0 ½ 1 MILE; 0 2000 4000 6000 8000 FEET

A new wastewater treatment facility to serve the Wind Lake sewer service area was under construction in 1978. This facility is being constructed by the Town of Norway Sanitary District No. 1, and is proposed by the District to provide sewer service not only to the urban development on the Wind Lake shoreline, but to existing urban development on the shores of Waubeesee and Long Lakes in the Town of Norway and Lake Denoon in the City of Muskego. The plant will provide secondary and tertiary waste treatment with conventional advanced waste treatment for phosphorus removal and nitrification. The areawide water quality management plan proposes that, at a later time in the plan implementation period, this plant be upgraded to provide a higher level of phosphorus removal, or discharge of effluent to a land application system.

*Source: SEWRPC.*

## Proposed Plan-Eagle Lake Subarea

In 1978 the new wastewater treatment plant for the Town of Dover-Eagle Lake Sewer Utility District was under construction. The plant is designed with an average hydraulic capacity of 0.40 mgd. The new wastewater treatment plant is designed to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Eagle Creek. The planned sewer service area includes the urban development around Eagle Lake as described in the Fox River watershed plan, as well as additional urban development in the unincorporated village of Kansasville as recommended by engineering studies completed for the District. It is anticipated that existing development and future growth will require an average hydraulic design capacity for the Eagle Lake sewer service area of about

Table 169

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WIND LAKE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Wind Lake | 0.99 | 1.55 | Wind Lake | 4,600 | 7,400 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br><br>Phosphorus Removal<br>Effluent Aeration<br><br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Waubeesee Lake drainage canal.*

*Source: SEWRPC.*

Table 170

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WIND LAKE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Town of Norway Sanitary District No. 1 . . . . | $4,226,000 | $210,000 | $3,196,000 | $3,099,000 | $6,295,000 | $203,000 | $197,000 | $400,000 |
| Tunk Sewer Muskego-Norway . . . . . . . | 77,000 | 5,000 | 487,000 | 67,000 | 554,000 | 31,000 | 4,000 | 35,000 |
| Total | $5,003,000 | $215,000 | $3,683,000 | $3,166,000 | $6,849,000 | $234,000 | $201,000 | $435,000 |

*Source: SEWRPC.*

0.32 mgd in 1985 and about 0.38 mgd in the year 2000. This year 2000 design flow is slightly larger than the estimated 1990 design flow of 0.30 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for Eagle Creek and the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for aeration and disinfection. The recommendations concerning treatment and discharge to surface waters differ from the recommendations contained in the regional sanitary sewerage system plan only with regard to the provision of advanced waste treatment for phosphorus removal. That plan recommended the provision of secondary waste treatment plus conventional advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection.

As previously noted, the Town of Dover-Eagle Lake Sewer Utility District wastewater treatment facility is presently under construction, with completion scheduled for 1978. The new facility will provide for secondary waste treatment followed by advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. These proposed facilities represent a major step toward the implementation of the treatment and discharge alternative. In view of the existing stage of implementation, the decision to provide advanced waste treatment followed by discharge to the surface water has been treated as a committed local decision, even though the areawide analysis indicates that, on a generalized basis, the land application alternative may be less costly than providing the levels of treatment needed prior to discharge to surface waters. Future facilities planning efforts designed to evaluate the phosphorus reduction component of the recommendations should further consider the land application alternative. The recommended performance standards for the Eagle Lake wastewater treatment plant are set forth in Table 171, and the proposal is shown on Map 78.

The total present worth over 50-year analysis period of construction and operation of the proposed treatment facilities for the Eagle Lake sewer service area is about $2,921,000. The estimated capital cost for constructing the necessary treatment facilities is $1,825,000, with an estimated average annual operation and maintenance cost of $108,000 (see Table 172).

Proposed Plan—Waterford-Rochester and Tichigan Lake Subareas

In 1975 the wastewater treatment facility operated by the Western Racine County Sewerage District and serving the Waterford-Rochester sewer service area had an average hydraulic design capacity of 0.50 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Waterford-Rochester and Tichigan Lake sewer service areas of about 1.25 mgd in 1985 and about 1.50 mgd in the year 2000. This

Table 171

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAGLE LAKE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Town of Dover Sewer Utility | 0.32 | 0.38 | Eagle Lake | 1,500 | 1,800 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal[b]<br>Effluent Aeration<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Eagle Creek.*

*Source: SEWRPC.*

Table 172

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAGLE LAKE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Town of Dover-Eagle Lake Sewer Utility District. . . . . | $1,825,000 | $108,000 | $1,380,000 | $1,541,000 | $2,921,000 | $87,000 | $98,000 | $185,000 |
| Total | $1,825,000 | $108,000 | $1,380,000 | $1,541,000 | $2,921,000 | $87,000 | $98,000 | $185,000 |

*Source: SEWRPC.*

Map 78

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE EAGLE LAKE SEWER SERVICE AREA— LOWER FOX RIVER SUBREGIONAL AREA: 2000**


A new wastewater treatment facility to serve the Eagle Lake sewer service area was under construction in 1978. This facility is being constructed by the Town of Dover-Eagle Lake Sewer Utility District. The District has proposed to extend service to the nearby unincorporated Village of Kansasville. The plant will provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection. The areawide water quality management plan proposes that, at a later time in the plan implementation period, this plant be upgraded to provide a high level of phosphorus removal, or discharge of effluent to a land application system.

*Source: SEWRPC.*

year 2000 design flow is the same as the estimated 1990 design flow of 1.50 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for disinfection. The recommendations concerning treatment and discharge to surface waters differ from the recommendations contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that the Western Racine County Sewerage District plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and effluent land application would be less costly then providing secondary waste treatment followed by a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment for treatment plants the size of the Western Racine County Sewerage District facility. Accordingly, the areawide water quality management plan is based upon the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative.

Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l. The recommended performance standards for the Western Racine County Sewerage District wastewater treatment plant are set forth in Table 173, and proposal is shown on Map 79.

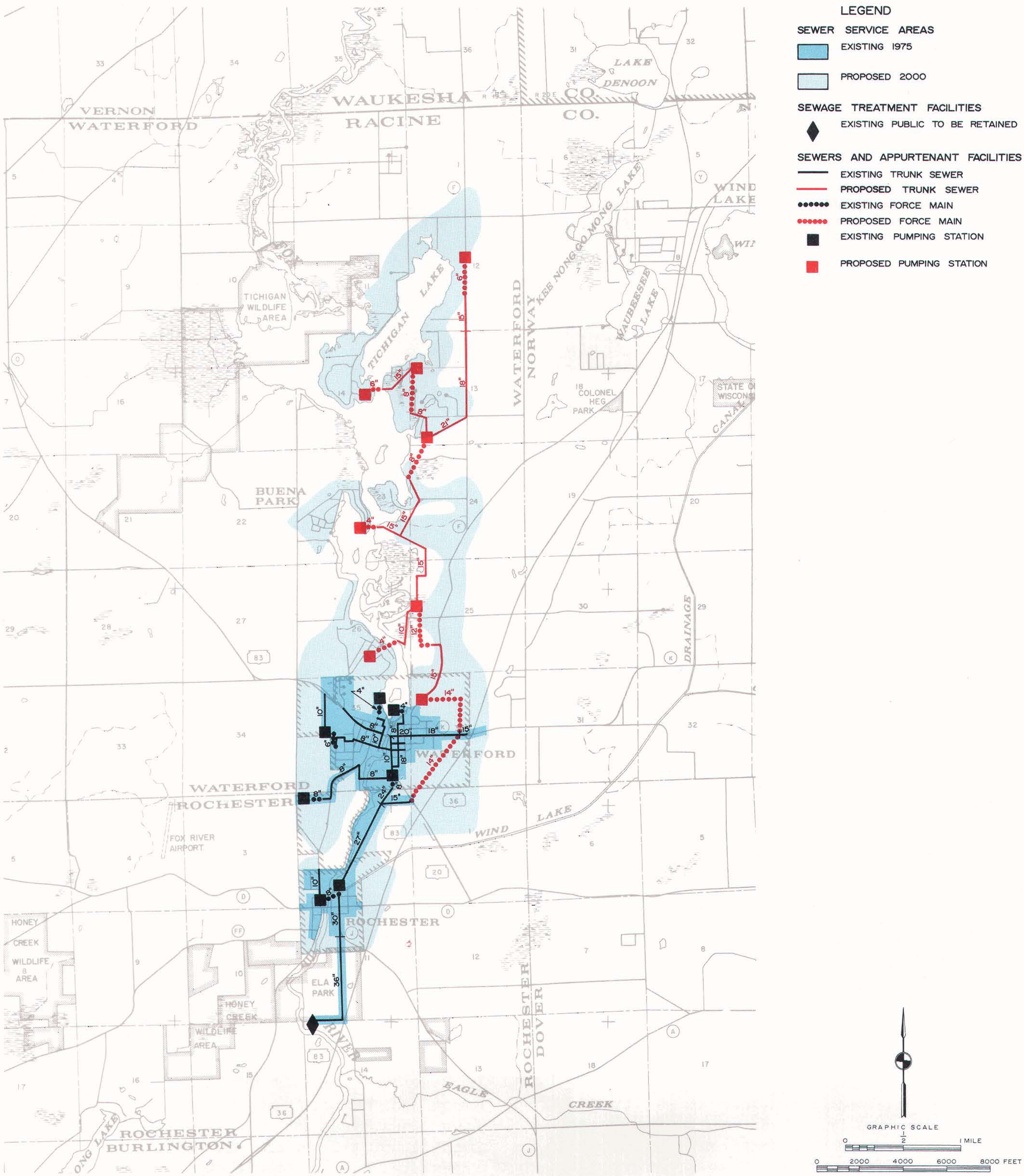
The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Waterford-Rochester and Tichigan Lake sewer service areas is about $8,812,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $8,080,000, with an estimated average annual operation and maintenance cost of $215,000 (see Table 174).

Alternative Plans—Burlington Subarea

In 1975 the wastewater treatment facility serving the Burlington sewer service area had an average hydraulic design capacity of 2.50 mgd, and provided a secondary level of waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection. It is anticipated that future growth will require an average hydraulic design

Map 79

## PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WATERFORD-ROCHESTER AND TICHIGAN LAKE SEWER SERVICE AREAS—LOWER FOX RIVER SUBREGIONAL AREA: 2000




The proposed plan for the Rochester-Waterford and Tichigan Lake sewer service areas of the Lower Fox River watershed includes a recommendation to expand the Rochester sewage treatment facility operated by the Western Racine County Sewerage District so as to provide capacity for sewage generated by existing urban development along the shoreline of Tichigan Lake and the main stem of the Fox River in the Town of Waterford north of the Village of Waterford. The proposed plan, as shown on the above map, includes a recommended trunk sewer system to extend the existing sanitary sewerage system to the Town of Waterford. In order to meet the established water use objectives for the Fox River watershed, this plant will need to provide either land application of plant effluent following secondary level of treatment, or a secondary waste treatment with a high level of advanced waste treatment for phosphorus and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.

*Source: SEWRPC.*

Table 173

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WATERFORD-ROCHESTER AND TICHIGAN LAKE SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Western Racine County Sewerage District | 1.25 | 1.50 | Waterford-Rochester and Tichigan Lake | 8,200 | 9,400 | Secondary<br>Auxiliary | Activated Sludge<br>Disinfection | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| | | | | | | Advanced | Land Application | - - |

[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment plus conventional advanced waste treatment for phosphorus removal followed by auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.*

*Source: SEWRPC.*

Table 174

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WATERFORD-ROCHESTER AND TICHIGAN LAKE SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant<br>Western Racine County<br>Sewerage District | | | | | | | | |
| Facilities. . . . . . . . . . . | $4,576,000 | $176,000 | $3,545,000 | $2,579,000 | $6,124,000 | $225,000 | $163,000 | $388,000 |
| Land . . . . . . . . . . . . . | 473,000 | - - | 271,000 | - - | 271,000 | 17,000 | - - | 17,000 |
| Subtotal | $5,049,000 | $176,000 | $3,816,000 | $2,579,000 | $6,395,000 | $242,000 | $163,000 | $405,000 |
| Trunk Sewer<br>Tichigan Lake-Rochester. . . | 3,031,000 | 39,000 | 1,902,000 | 515,000 | 2,417,000 | 121,000 | 33,000 | 154,000 |
| Total | $8,080,000 | $215,000 | $5,718,000 | $3,094,000 | $8,812,000 | $363,000 | $196,000 | $559,000 |

*Source: SEWRPC.*

capacity for the Burlington sewer service area of about 2.01 mgd in 1985 and about 2.70 mgd in the year 2000. This year 2000 design flow is larger than the estimated 1990 design flow of 2.50 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that the plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the general analysis described earlier in this chapter, the effluent land application alternative and the treatment and discharge alternative should be considered further for a plant the size of the Burlington facility.

Accordingly, two treatment alternatives were considered for the Burlington sewer service area. The first alternative would provide for continued discharge of the Burlington wastewater treatment plant effluent to the Fox River following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the provision of a land application system for disposal of secondary treatment plant effluent from the Burlington facility. The recommended wastewater treatment plant performance standards for both of the alternatives are set forth in Table 175, and the two proposals are shown on Map 80.

The first alternative is based upon the provision of secondary waste treatment with advanced waste treatment for phosphorus removal utilizing conventional chemical treatment for phosphorus removal, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to the Fox River. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities included under Alternative Plan 1 for the Burlington sewer service area is about $9,088,000. The estimated capital cost for constructing the necessary additional treatment facilities is $3,147,000, with an estimated average annual operation and maintenance cost of $437,000 (see Table 176).

The second alternative treatment system is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural lands in the Towns of Rochester and Burlington were selected to receive the effluent from the Burlington wastewater treatment facility. These sites would require that the effluent be pumped about 13,000 feet. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Burlington sewer service area is about $13,659,000. The estimated capital cost for constructing the necessary additional treatment facilities is $9,931,000, with an estimated average annual operation and maintenance cost of $327,000 (see Table 176).

On an equivalent annual cost basis, including the cost of the sludge-related facilities required under the first alternative, Alternative Plan 1 would be about 20 percent less costly to implement than would Alternative Plan 2. In addition, Alternative Plan 1 could be more readily implemented since construction of most of the major components of the alternative is complete, and since this alternative represents a continuation of existing practices with the added construction and operational requirements associated with the recommended expansion and upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 1,000 acres of land, which would result in a major change in agricultural land management for the selected application site

Table 175

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BURLINGTON SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | *Recommended* Performance Standards in Terms of Effluent Quality (all standards represent average monthly (limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Burlington | 2.01 | 2.70 | Burlington | 13,300 | 16,500 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of Burlington | 2.01 | 2.70 | Burlington | 13,300 | 16,500 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Effluent Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br><br>- - |

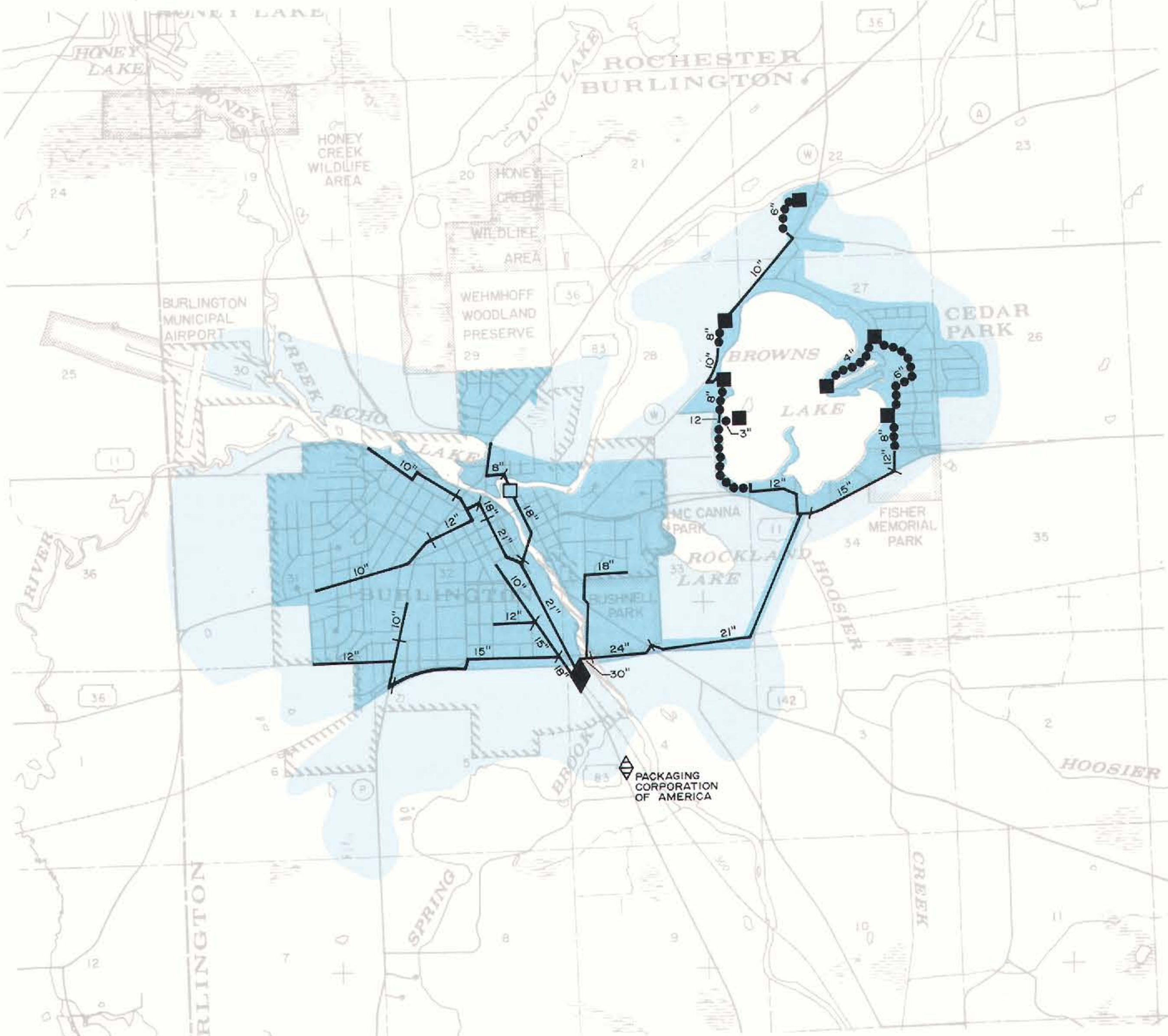
[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment plus advanced waste treatment for phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) followed by auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.*

*Source: SEWRPC.*

Map 80

## ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BURLINGTON SEWER SERVICE AREA—LOWER FOX RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

EXISTING PUMPING STATION

EXISTING LIFT STATION

GRAPHIC SCALE

0 ½ 1 MILE

0 2000 4000 6000 FEET

The areawide water quality management plan proposes that the existing Burlington treatment plant be expanded to meet the anticipated year 2000 needs of the Burlington sewer service area. In order to meet the established water use objectives for the Fox River, it will be necessary for the Burlington plant to be upgraded to provide either land application of plant effluent following a secondary level of treatment, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of total phosphorus of 0.1 mg/l—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Fox River. The alternative calling for the provision of advanced waste treatment prior to discharge to the surface water would be less costly than the effluent land application alternative.

*Source: SEWRPC.*

Table 176

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE BURLINGTON SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant City of Burlington Facilities. . . . . . . . . . . | $3,147,000 | $437,000 | $2,380,000 | $6,708,000 | $ 9,088,000 | $151,000 | $426,000 | $577,000 |
| Subtotal | $3,147,000 | $437,000 | $2,380,000 | $6,708,000 | $ 9,088,000 | $151,000 | $426,000 | $577,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $3,147,000 | $437,000 | $2,380,000 | $6,708,000 | $ 9,088,000 | $151,000 | $426,000 | $577,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant City of Burlington Facilities. . . . . . . . . . . | $9,022,000 | $327,000 | $7,845,000 | $5,293,000 | $13,138,000 | $498,000 | $336,000 | $834,000 |
| Land . . . . . . . . . . . . . | 909,000 | - - | 521,000 | - - | 521,000 | 33,000 | - - | 33,000 |
| Subtotal | $9,931,000 | $327,000 | $8,366,000 | $5,293,000 | $13,659,000 | $531,000 | $336,000 | $867,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $9,931,000 | $327,000 | $8,366,000 | $5,293,000 | $13,659,000 | $531,000 | $336,000 | $867,000 |

[a] *This alternative does not include the cost of additional facilities related to the increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the added sludge-handling and -disposal requirements is $1,450,000. The estimated capital cost for construction of the added sludge-related facilities is $990,000, with an estimated average annual operation and maintenance cost of $44,000 over the design period 1975-2000.*

*Source: SEWRPC.*

area, and requires that treatment plant managers become involved in agricultural land management. Alternative Plan 2 also requires the construction of a major conveyance system to transport the treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1.

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from the wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, based on the economic advantage, environmental impacts, and ease of implementation, Alternative Plan Plan 1—the treatment and discharge alternative—is recommended.

Proposed Plan—Silver Lake Subarea

In 1975 the wastewater treatment facility serving the Silver Lake sewer service area had an average hydraulic design capacity of 0.30 mgd, and provided a secondary level of waste treatment and auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Silver Lake sewer service area of about 0.28 mgd in 1985 and about 0.38 mgd in the year 2000. This year 2000 design flow is considerably less than the estimated 1990 design flow of 0.70 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with a conventional advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 1.0 mg/l of total phosphorus—and auxiliary waste treatment for disinfection. The recommendations concerning treatment and discharge to surface waters is the same as those contained in the regional sanitary sewerage system plan.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application would be a viable alternative to providing secondary waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for plants the size of the Silver Lake facility. Thus, the areawide water quality management plan is based upon the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. The recommended performance standards for the Silver Lake wastewater treatment plant are set forth in Table 177, and the proposal is shown on Map 81.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Silver Lake sewer service area is about $2,994,000. The estimated capital cost for constructing the necessary additional treatment facilities is $2,151,000, with an estimated average annual operation and maintenance cost of $88,000 (see Table 178).

Proposed Plan—Twin Lakes Subarea

In 1975 the wastewater treatment facility serving the Twin Lakes sewer service area had an average hydraulic design capacity of 0.82 mgd and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Town Lakes sewer service area of about 0.89 mgd in 1985 and about 1.00 mgd in the year 2000. This year 2000 design flow is somewhat larger than the estimated 1990 design flow of 0.75 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for Basset Creek and the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for aeration and disinfection. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that the Twin Lakes plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application would be a viable alternative to providing secondary waste treatment followed by conventional advanced waste treatment for nitrifi-

Table 177

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SILVER LAKE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Silver Lake | 0.28 | 0.38 | Silver Lake | 1,900 | 2,400 | Secondary | Activated Sludge Disinfection | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| | | | | | | Advanced | Land Application[b] | - - |

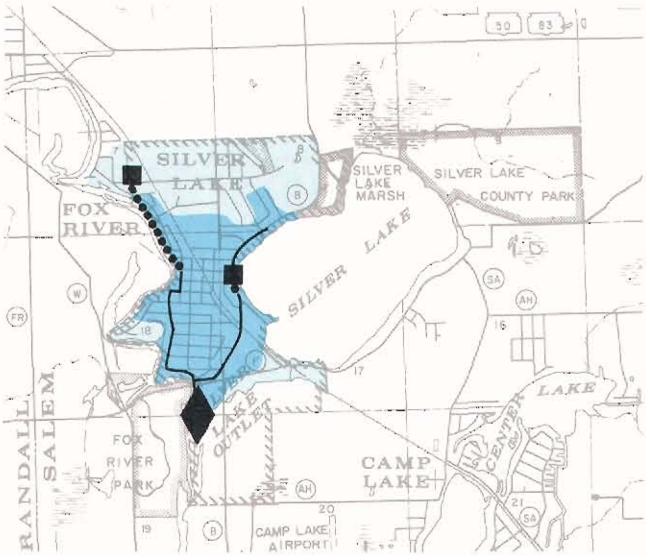
[a] *See Map 71.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment plus conventional advanced waste treatment for phosphorus removal, followed by auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.*

*Source: SEWRPC.*

Map 81

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SILVER LAKE SEWER SERVICE AREA— LOWER FOX RIVER SUBREGIONAL AREA: 2000**




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE RETAINED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

EXISTING FORCE MAIN

EXISTING PUMPING STATION

GRAPHIC SCALE

0 1/2 1 MILE

0 2000 4000 6000 8000 FEET

The areawide water quality management plan proposes that the Silver Lake wastewater treatment plant be expanded and upgraded to meet the year 2000 needs. In order to meet the established water use objectives for the Fox River, this facility will need to provide either land application of plant effluent following the current secondary level of waste treatment, or secondary waste treatment with conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.

*Source: SEWRPC.*

cation, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment plants the size of the Twin Lakes facility.

Thus, the areawide water quality management plan is based upon the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l. The recommended performance standards for the Twin Lakes wastewater treatment plant are set forth in Table 179, and the proposal is shown on Map 82.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Twin Lakes sewer service area is about $4,920,000. The estimated capital cost for constructing the necessary additional treatment facilities is $3,362,000, with an estimated average annual operation and maintenance cost of $155,000 (see Table 180).

Proposed Plan—Camp-Center Lakes, Wilmot, Cross Lake, and Rock Lake Subareas

No public sanitary sewer service is currently being provided to the Camp-Center Lakes, Wilmot, Cross Lake, and Rock Lake sewer service areas. Both local facility planning and the regional sanitary sewerage system plan propose that centralized sanitary sewer service be provided to these sewer service areas by a treatment facility to be operated by the Town of Salem Sewer Utility District No. 2. It is anticipated that an average hydraulic design capacity for the Town of Salem Utility District No. 2 sewer service area will be about 1.42 mgd in 1985 and 1.97 mgd in the year 2000. This year 2000 design flow is considerably larger than the estimated 1990 design flow of 1.00 mgd anticipated under the regional sanitary sewerage system plan.

In 1978 facility planning for the Town of Salem Utility District No. 2 had been completed, and an environmental impact statement is being prepared for the proposed project by the U. S. Environmental Protection Agency. That local facility plan proposed that centralized wastewater treatment be provided at a treatment plant located southwest of Camp-Center Lake, with discharge of the plant effluent to the Fox River main stem via an outfall sewer. The proposed wastewater treatment plant is designed to provide secondary waste treatment with advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. The plant is proposed to have an average hydraulic design capacity of about 1.50 mgd.

In order to meet established water use objectives for the Fox River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary

Table 178

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SILVER LAKE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Silver Lake | | | | | | | | |
| Facilities. . . . . . . . . . . | $2,003,000 | $88,000 | $1,542,000 | $1,367,000 | $2,909,000 | $ 98,000 | $87,000 | $185,000 |
| Land . . . . . . . . . . . . . | 148,000 | - - | 85,000 | - - | 85,000 | 5,000 | - - | 5,000 |
| Subtotal | $2,151,000 | $88,000 | $1,627,000 | $1,367,000 | $2,994,000 | $103,000 | $87,000 | $190,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $2,151,000 | $88,000 | $1,627,000 | $1,367,000 | $2,994,000 | $103,000 | $87,000 | $190,000 |

Source: SEWRPC.

Table 179

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE TWIN LAKES SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Twin Lakes | 0.89 | 1.00 | Twin Lakes | 5,700 | 6,200 | Secondary | Activated Sludge | $BOD_5$ Discharge: 30 mg/l |
| | | | | | | Auxiliary | Disinfection | Fecal Coliform Concentration: 200/100 ml |
| | | | | | | Advanced | Land Application | - - |

[a] See Map 71.

[b] This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which provided for secondary waste treatment plus conventional advanced waste treatment for phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and nitrification followed by auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Basset Creek.

Source: SEWRPC.

Table 180

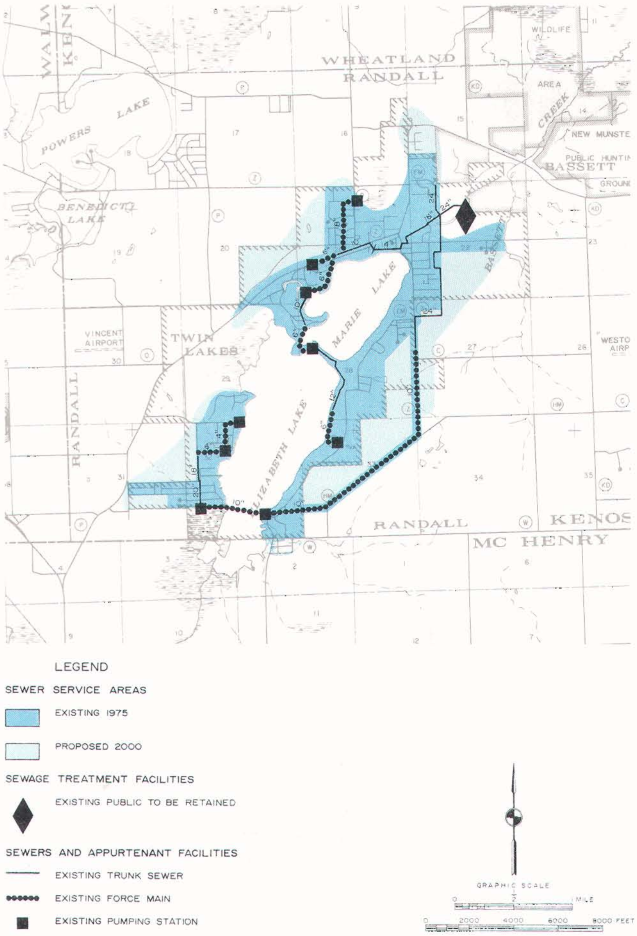
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE TWIN LAKES SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Twin Lakes | | | | | | | | |
| Facilities. . . . . . . . . . . | $3,037,000 | $155,000 | $2,356,000 | $2,378,000 | $4,734,000 | $149,000 | $151,000 | $300,000 |
| Land . . . . . . . . . . . . . | 325,000 | - - | 186,000 | - - | 186,000 | 12,000 | - - | 12,000 |
| Subtotal | $3,362,000 | $155,000 | $2,542,000 | $2,378,000 | $4,920,000 | $161,000 | $151,000 | $312,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $3,362,000 | $155,000 | $2,542,000 | $2,378,000 | $4,920,000 | $161,000 | $151,000 | $312,000 |

Source: SEWRPC.

Map 82

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE TWIN LAKES SEWER SERVICE AREA— LOWER FOX RIVER SUBREGIONAL AREA: 2000**




The areawide water quality management plan proposes that the existing Twin Lakes treatment plant be upgraded to meet the anticipated year 2000 needs. In order to meet the established water use objectives for Basset Creek and the Fox River, this plant will need to provide either land application of plant effluent following the current secondary level of treatment, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Basset Creek.

*Source: SEWRPC.*

waste treatment with a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for disinfection. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that the plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As previously noted, the local facility planning for the Town of Salem Sewer Utility District No. 2 has been completed, with completion of the Environmental Impact Statement anticipated in 1978. The treatment facilities proposed will provide for secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection. These facilities represent a major step toward implementation of the treatment and discharge alternative. In view of the existing stage of implementation, the decision to provide advanced waste treatment followed by discharge to surface waters has been treated as a committed local decision even though the areawide analysis indicates that, on a generalized basis, the land application alternative may be less costly than providing the levels of treatment needed prior to discharge to surface waters. Should the findings of the environmental impact study presently being conducted and subsequent local plan revision determine that an alternative treatment process is more desirable, those findings will be incorporated into the areawide water quality management plan upon adoption by all the parties involved. Future facilities planning efforts designed to evaluate the phosphorus reduction component of the proposal should further consider the land application alternative. The recommended performance standards for the Camp-Center Lakes wastewater treatment plant are set forth in Table 181, and the proposal is shown on Map 83.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Camp-Center Lakes, Wilmot, Cross Lake, and Rock Lake sewer service areas is about $8,477,000. The estimated capital cost for constructing the proposed treatment and conveyance facilities is $7,359,000, with an estimated average annual operation and maintenance cost of $241,000 (see Table 182).

Proposed Plan—North Prairie Subarea

No sanitary sewer service is presently being provided to the North Prairie sewer service area. The areawide water quality management plan proposes a new sanitary sewerage system to serve the urban development of the Village. It is anticipated that an average hydraulic design capacity for the North Prairie sewer service area will be about 0.19 mgd in 1985 and about 0.36 mgd in the year 2000.

In order to meet established water use objectives for the Fox River and its tributaries, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent,

Table 181

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS–PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE CAMP-CENTER LAKES, WILMOT, CROSS LAKE, AND ROCK LAKE SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Town of Salem Sewer Utility District No. 2 | 1.42 | 1.97 | Camp-Center Lakes, Wilmot, Cross Lake, and Rock Lake | 5,800 | 7,800 | Secondary<br>Advanced<br>Auxiliary | Activated Sludge<br>Phosphorus Removal<br>Disinfection | $BOD_5$ Discharge: 15 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 71.*

[b] *This treatment standard is more stringent than the one included under the regional sanitary sewerage system plan, which recommended secondary waste treatment followed by conventional advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to the Fox River.*

*Source: SEWRPC.*

Table 182

DETAILED ECONOMIC ANALYSIS COST ESTIMATES–PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE CAMP-CENTER LAKES, WILMOT, CROSS LAKE, AND ROCK LAKE SEWER SERVICE AREAS: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant<br>Town of Salem Sewer<br>Utility District No. 2 | | | | | | | | |
| Facility . . . . . . . . . . . | $3,262,000 | $210,000 | $2,467,000 | $3,038,000 | $5,505,000 | $157,000 | $193,000 | $350,000 |
| Outfall Sewer . . . . . . . . | 656,000 | 1,000 | 406,000 | 12,000 | 418,000 | 26,000 | 1,000 | 27,000 |
| Subtotal | $3,918,000 | $211,000 | $2,873,000 | $3,050,000 | $5,923,000 | $183,000 | $194,000 | $377,000 |
| Trunk Sewers | | | | | | | | |
| Cross-Rock Lakes. . . . . . . | $1,928,000 | $ 11,000 | $1,210,000 | $ 141,000 | $1,351,000 | $ 77,000 | $ 9,000 | $ 86,000 |
| Silver Lake-Camp Lake. . . . | 1,113,000 | 15,000 | 698,000 | 202,000 | 900,000 | 44,000 | 13,000 | 57,000 |
| Wilmot. . . . . . . . . . . . . | 400,000 | 4,000 | 251,000 | 52,000 | 303,000 | 16,000 | 3,000 | 19,000 |
| Subtotal | $3,441,000 | $ 30,000 | $2,159,000 | $ 395,000 | $2,554,000 | $137,000 | $ 25,000 | $162,000 |
| Total | $7,359,000 | $241,000 | $5,032,000 | $3,445,000 | $8,477,000 | $320,000 | $219,000 | $539,000 |

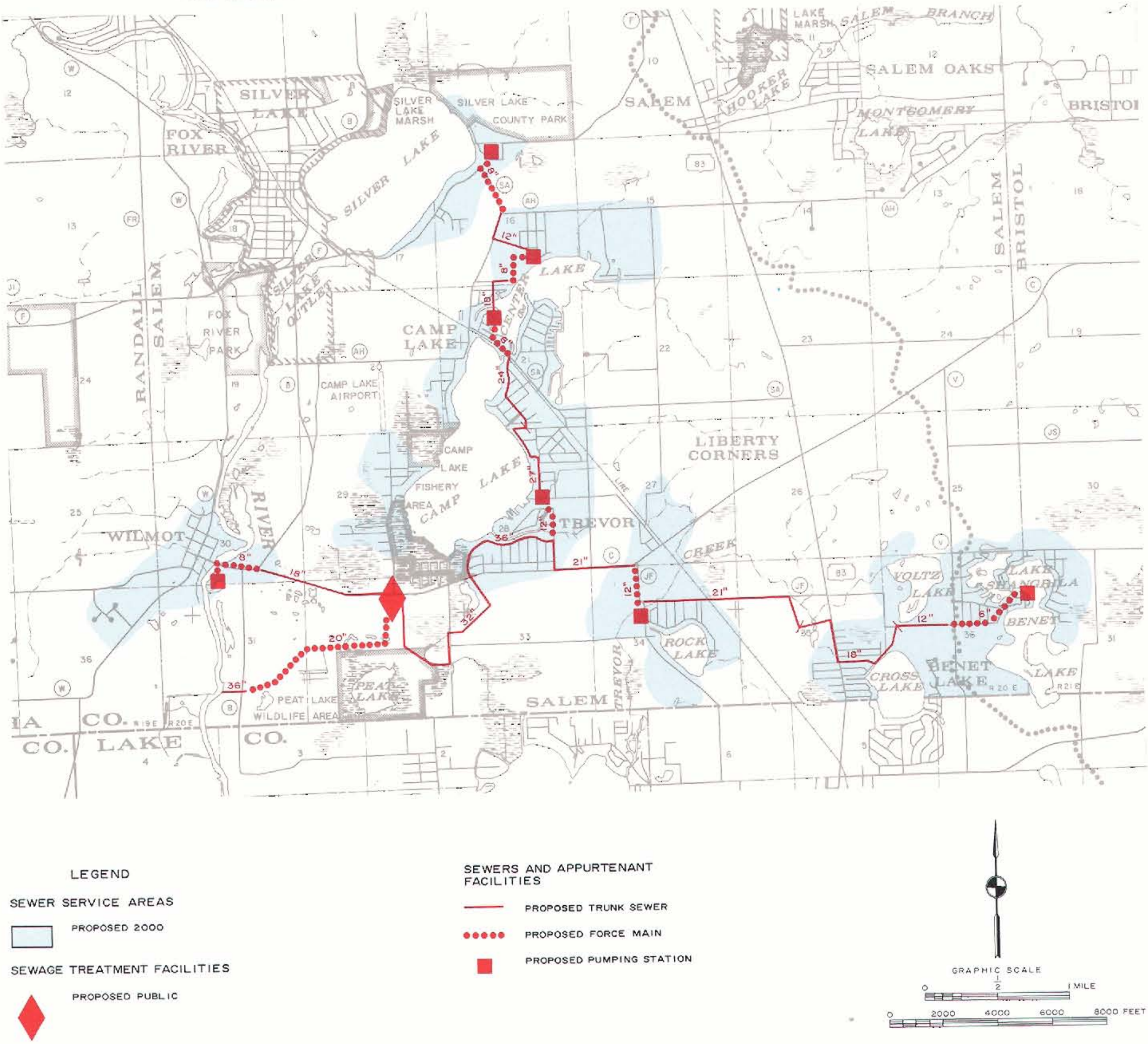
*Source: SEWRPC.*

or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for aeration and disinfection.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and effluent land application would be less costly than providing secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for plants the size of the North Prairie facility. The recommendation of the areawide water quality management planning program is based upon the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning

Map 83

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE CAMP-CENTER LAKES, WILMOT, CROSS LAKE, AND ROCK LAKE SEWER SERVICE AREAS—LOWER FOX RIVER SUBREGIONAL AREA: 2000




The adopted Fox River watershed plan recommended the establishment of a new sanitary sewerage system to serve existing urban development along the shorelines of Camp and Center Lakes in the Town of Salem. Facility planning studies conducted by the Town of Salem Sewer Utility District No. 2 in response to this recommendation have included a proposal to extend such service not only to the Camp and Center Lakes urban areas, but to urban development along the shorelines of Rock, Cross, Bennet, Shangrila, and Voltz Lakes and to the unincorporated Villages of Wilmot and Trevor. The above map shows the proposed treatment plant location and major trunk sewer system. In order to meet the established water use objectives for the Fox River, it will be necessary for the Camp Lake facility to provide not only secondary waste treatment, but a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection.

*Source: SEWRPC.*

efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l. The recommended performance standards for the North Prairie wastewater treatment plant are set forth in Table 183, and the proposal is shown on Map 84.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the North Prairie sewer service area is about $2,447,000. The estimated capital cost for constructing the necessary additional treatment facilities is $2,143,000, with an estimated average annual operation and maintenance cost of $55,000 (see Table 184).

Private Wastewater Treatment Plants

There are 13 known private wastewater treatment facilities in the Lower Fox River subregional area which in general serve isolated enclaves of urban land uses and treat wastes which can be accepted in public sanitary sewer systems. These facilities currently discharge relatively minor amounts of treated wastewaters to the streams and groundwater in the Lower Fox River subregional area. These facilities serve the Alpine Valley Resort and the Wisconsin Department of Transportation East Troy Rest Area in the Town of LaFayette; Country Estates Mobile Home Park and the Playboy Club Hotel in the Town of Lyons; Praiser Produce Company and the Wisconsin Dairies Cooperative in the Village of Genoa City; Slovak Sokol Camp in the Town of East Troy; Rainbow Springs Resort in the Town of Mukwonago; Wheatland Mobile Home Park in the Town of Wheatland; Downey Duck Company and Holy Redeemer College in the Town of Dover; Packaging Corporation of America in the Town of Burlington and the Interlaken Resort Village in the Town of Geneva. Praiser Produce Com-

Table 183

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE NORTH PRAIRIE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of North Prairie | 0.19 | 0.36 | North Prairie | 900 | 1,700 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br>Spray Irrigation<br>Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br><br>- - |

[a] *See Map 71.*

*Source: SEWRPC.*

Table 184

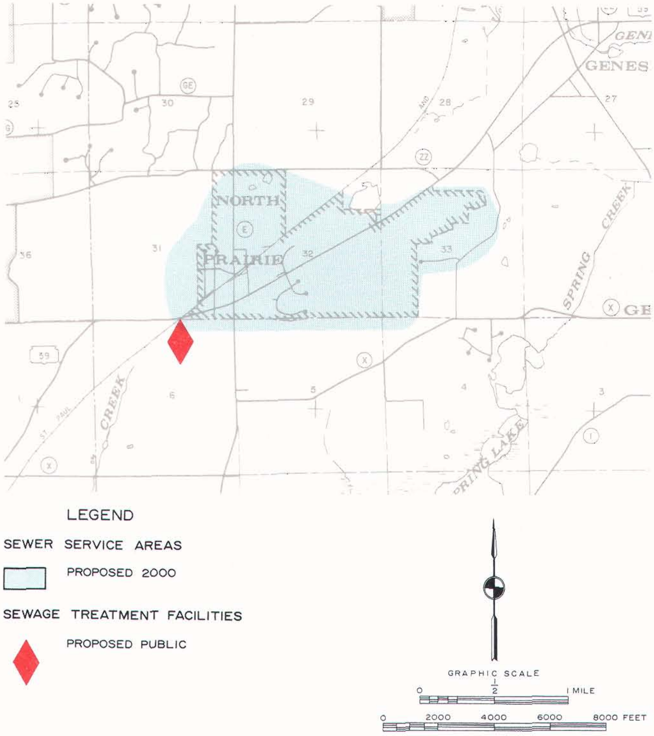
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE NORTH PRAIRIE SEWER SERVICE AREA: LOWER FOX RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant<br>Village of North Prairie | | | | | | | | |
| Facilities. . . . . . . . . . . | $2,000,000 | $55,000 | $1,539,000 | $826,000 | $2,365,000 | $ 98,000 | $52,000 | $150,000 |
| Land . . . . . . . . . . . . . | 143,000 | - - | 82,000 | - - | 82,000 | 5,000 | - - | 5,000 |
| Subtotal | $2,143,000 | $55,000 | $,1621,000 | $826,000 | $2,447,000 | $103,000 | $52,000 | $155,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $2,143,000 | $55,000 | $1,621,000 | $826,000 | $2,447,000 | $103,000 | $52,000 | $155,000 |

*Source: SEWRPC.*

Map 84

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE NORTH PRAIRIE SEWER SERVICE AREA—LOWER FOX RIVER SUBREGIONAL AREA: 2000




Currently, the Village of North Prairie and environs rely on private septic tank sewage disposal systems for the treatment and disposal of wastewater. Predicted growth trends and existing problems with onsite wastewater disposal systems have indicated the need for a centralized sanitary sewerage system. In order to meet the established water use objectives for the Fox River tributaries in the vicinity of the Village, the proposed wastewater treatment plant will need to provide a secondary level of wastewater treatment followed by land application of plant effluent, or provide secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the surface waters.

*Source: SEWRPC.*

pany, Slovak Sokol Camp, the Interlaken Resort Village, Wisconsin Dairies Cooperative, and Packaging Corporation of America lie within the proposed year 2000 sewer service area. The treatment facilities serving these establishments would be abandoned upon implementation of the proposed sewer system plan for the appropriate sewer service area. The remaining eight facilities should be retained and, as necessary, upgraded to provide a level of treatment adequate to meet the water use objectives and standards for streams within the Fox River subregional area, and consistent with the treatment levels proposed for the public plants discharging to the same or similar surface waters.

Based upon the general analysis described earlier in this chapter, land application of plant effluent is considered to be less costly and more viable than providing advanced waste treatment prior to discharge to surface waters for facilities the size of the private plants noted above to be retained. The new private plant was placed into operation at the Alpine Valley Resort since 1975. It is recommended that the operation of the older facility serving the Alpine Valley Main Building be carefully monitored and that this plant be considered an interim facility. At such time as the operation becomes unsatisfactory, it is recommended that the plant be abandoned and all wastes be conveyed to the new Alpine Valley Fox Wood treatment plant. The proposed plan for these plants is based upon the provision of land application of plant effluent (see Table 185).

Should local facility planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with the effluent discharged to surface waters should be considered.

The estimated present worth of construction and operation of the private wastewater treatment facilities in the Lower Fox River subregional area over a 50-year analysis period is $4,270,000. The estimated capital cost for constructing the necessary facilities is $3,020,000, with an estimated average annual operation and maintenance cost of $126,000.

## Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are 27 enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area as shown on Map 71. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are listed in Table 186. In an alternative analysis described earlier in this chapter, the cost of providing public sewerage service to these enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that analysis, it was concluded that wastewater treatment for these 27 enclaves of unsewered urban development should be provided in one of two ways.

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan proposal is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. Fourteen of the 27 unsewered urban areas are included in this category—New Munster, the Town of Bloomfield—Section 7, Lake Ivanhoe, Lake Wandawega and Silver Lake, Mill Lake, Pell Lake, Troy Center, Zenda, the Town of Mukwonago—Section 7, the Town of Mukwonago—Sections 9, 15, and 21, the Town of Vernon—Section 12 and Section 19, Big Bend, and Eagle.

For the remaining enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. These areas, which should consider alternative methods of onsite waste disposal and an intensive inspection and maintenance program for conventional systems, as well as the possibility of connection to the public sanitary sewer service area, are: the Town of Wheatland—Section 25, Lilly Lake, Powers and Benedict Lakes, Silver Lake-

Table 185

WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE LOWER FOX RIVER SUBREGIONAL AREA

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| Alpine Valley Resort, Inc. | Town of Lafayette | Recreational | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Country Estates Mobile Home Park | Town of Lyons | Residential | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Downey Duck Company, Inc. | Town of Dover | Industrial | Process and Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Holy Redeemer College | Town of Dover | Institutional | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Playboy Club Hotel | Town of Lyons | Recreational | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Rainbow Springs Resort | Town of Mukwonago | Recreational | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Wheatland Mobile Home Park | Town of Wheatland | Residential | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Wisconsin Department of Transportation— East Troy Rest Area | Town of Lafayette | Transportation | Sanitary | Land Application | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

*Source: SEWRPC.*

Northwest, Bohner Lake, the Town of Lyons—Section 1, the Town of Troy—Section 3, Booth Lake, Lake Beulah, North Lake, Springfield, Vienna-Honey Lake, and Eagle Spring Lake. These areas generally have soil conditions and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

Sanitary Sewer System Flow Relief Devices

In 1975 there were four known sanitary sewer system flow relief devices in the Lower Fox River subregional area. The proposed plan recommends that local facilities planning efforts include the formulation of programs leading to the elimination of these sewage flow relief devices.

Other Known Point Sources of Wastewater

There are a total of 14 known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Lower Fox River subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of five-day biochemical oxygen demand ($BOD_5$), ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar surface water bodies. Thus, in most cases no further treatment recommendations were advanced for these other point sources with regard to these constituents. However, it is recommended that these point sources in general reduce discharge temperatures to $89^{\circ}F$ or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 187.

Table 186

EXISTING URBAN DEVELOPMENT
NOT SERVED BY PUBLIC SANITARY SEWERS
IN THE LOWER FOX RIVER SUBREGIONAL AREA
BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population | | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | | 1975 | 2000 | |
| | Kenosha County | | | |
| 1 | Town of Wheatland–Section 25 | 450 | 198 | 3.4 |
| 2 | Lilly Lake | 326 | 283 | 2.3 |
| 3 | New Munster | 126 | 145 | 3.4 |
| 4 | Powers and Benedict Lakes | 1,075 | 1,113 | 2.3 |
| 5 | Silver Lake-Northwest | 551 | 511 | - - |
| | Racine County | | | |
| 6 | Bohner Lake | 1,401 | 1,440 | 1.3 |
| | Walworth County | | | |
| 7 | Town of Bloomfield–Section 7 | 101 | 59 | 0.6 |
| 8 | Town of Lyons–Section 1 | 105 | 108 | 0.7 |
| 9 | Town of Troy–Section 3 | 117 | 69 | 4.9 |
| 10 | Booth Lake | 145 | 114 | - - |
| 11 | Lake Beulah | 678 | 612 | 0.6 |
| 12 | Lake Ivanhoe | 57 | 126 | 3.6 |
| 13 | Lake Wandawega and Silver Lake | 628 | 801 | 3.1 |
| 14 | Mill Lake | 252 | 293 | 4.2 |
| 15 | North Lake | 234 | 257 | 6.6 |
| 16 | Pell Lake | 1,336 | 1,419 | 2.2 |
| 17 | Springfield | 494 | 367 | 2.3 |
| 18 | Troy Center | 101 | 73 | 2.5 |
| 19 | Vienna-Honey Lake | 295 | 276 | 2.8 |
| 20 | Zenda | 117 | 100 | 2.0 |
| | Waukesha County | | | |
| 21 | Town of Mukwonago–Section 7 | 157 | 148 | 1.5 |
| 22 | Town of Mukwonago–Sections 9, 15, 21 | 307 | 738 | 1.9 |
| 23 | Town of Vernon–Section 12 | 182 | 229 | 1.0 |
| 24 | Town of Vernon–Section 19 | 249 | 233 | - - |
| 25 | Big Bend | 1,817 | 1,716 | 1.1 |
| 26 | Eagle | 817 | 1,201 | 3.4 |
| 27 | Eagle Spring Lake | 365 | 356 | 2.6 |
| Total | | 12,483 | 12,985 | 60.3 |

[a] *See Map 71.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

Table 187

REPORTED EFFLUENT CHARACTERISTICS FOR
KNOWN POINT SOURCES OTHER THAN SEWAGE
TREATMENT PLANTS AND SEWAGE FLOW RELIEF
DEVICES THAT REQUIRE TREATMENT CONSIDERATION–
LOWER FOX RIVER SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Culligan Soft Water Service Company . . . . . | City of Burlington | 0.001 | Fox River via Storm Sewer | Suspended Solids, Ammonia-Nitrogen |
| Lavelle Industries, Inc. . . . | City of Burlington | 0.055 | Fox River via Storm Sewer | $BOD_5$, Suspended Solids, Phosphorus, Heavy Metals |
| Coca Cola Bottling Company, Inc. . . . . . . | Town of Lyons | 0.007 | White River via Storm Sewer | $BOD_5$, Suspended Solids |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

The degree of treatment and costs of constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with other pretreatment requirements for existing discharges to public sanitary sewerage systems. However, in order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area, a cost estimate was made of the treatment requirements which appeared to be needed from the limited data available on these point sources. This estimate excludes existing industrial process system modifications designed to reduce pollutant discharge, existing industrial treatment facilities, and existing pretreatment systems utilized for treatment of waste conveyed to public sanitary sewerage systems. The total present worth over a 50-year analysis period of construction and operation of the treatment facilities needed to correct existing discharges of industrial wastes is estimated to be about $103,000. The capital cost for constructing the facilities is about $94,000, with an estimated average annual cost of $2,000 over the design period 1975 to 2000.

## UPPER ROCK RIVER SUBREGIONAL AREA

The Upper Rock River subregional area consists of all that part of the Rock River watershed in Washington County. This portion of the Rock River watershed is comprised of all or portions of several subwatersheds, including the East Branch of the Rock River subwatershed, the Kohlsville River subwatershed, the Limestone Creek subwatershed, the Rubicon River subwatershed, the Bark River subwatershed, the Ashippun River subwatershed, and the Oconomowoc River subwatershed. Concentrations of urban development are found in the City of Hartford, the Village of Slinger, and the unincorporated village of Allenton in the Town of Addison. In addition, the southern portion of this subregional area has been subject in recent years to extensive low-density urban residential development, particularly in the Towns of Erin and Richfield. The Upper Rock River subregional area contains all or portions of two major state-owned wildlife areas—the Theresa Marsh in the Town of Wayne and the Allenton Wildlife Area in the Town of Addison—as well as Pike Lake State Park, a major regional outdoor recreation facility.

Centralized sanitary sewer service in the Upper Rock River subregional area was provided by three systems in 1975: those operated by the City of Hartford, the Village of Slinger, and the Allenton Sanitary District No. 1. Together, the service areas of these three systems comprised about 2.6 square miles and served an estimated population of 9,700 persons. In 1975 there were about 15,500 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the three existing systems are presented in Volume

One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Sewer Service Analysis Area

A total of three sewer service analysis areas may be identified within the Upper Rock River subregional area (see Table 188). These three sewer service analysis areas are shown on Map 85, and may be described as follows:

1. Area A—This area consists of the unincorporated village of Allenton in the Town of Addison. In 1975 sanitary sewer service was provided in this area to about 0.2 square mile, having a total resident population of about 800 persons. The total area anticipated to be served by the year 2000 approximates 0.6 square mile, with a projected resident population of about 2,000 persons. This subarea is referenced as the "Allenton" service area in the ensuing discussion.

2. Area B—This area consists of the City of Hartford and environs. In 1975 sanitary sewer service was provided in this area to about 1.9 square miles, having a total resident population of about 7,600 persons. The total area anticipated to be served by the year 2000 approximates 5.2 square miles, with a projected resident population of about 15,500 persons. This subarea is referenced as the "Hartford" sewer service area in the ensuing discussion.

3. Area C—This area consists of the Village of Slinger and environs. In 1975 sanitary sewer service was provided in this area to about 0.5 square mile, having a total resident population of about 1,300 persons. The total area anticipated to be served by the year 2000 approximates 2.3 square miles, with a projected resident population of about 4,400 persons. This subarea is referenced as the "Slinger" sewer service area in the ensuing discussion.

Formulation of Alternatives

As noted earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system plan for the formulation and evaluation of alternative public sanitary sewerage system plans. First, the potential for interconnection of community sanitary sewerage systems was evaluated. One interconnection—Pike Lake to Hartford—was found to be potentially feasible through the application of Wisconsin Department of Natural Resources guidelines concerning distances between and population of communities. Preliminary economic analyses were then made for the interconnected system alternatives which were found to be potentially feasible, with a more detailed analysis conducted for those systems which continued to appear feasible following the preliminary analyses. A detailed economic analysis was made for two alternative plans for the Hartford-Pike Lake sewer service areas. One alternative provided for separate treatment of the wastewater from each service area, while the second alternative, which was ultimately recommended, provided for a joint treatment facility to serve both areas. A detailed discussion of these alternative proposals can be found in Chapter XI of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.

One significant modification to the regional sanitary sewerage system plan recommendations is incorporated into the areawide water quality management planning

Table 188

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE UPPER ROCK RIVER SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Population Served | Design Hydraulic Loading (mgd) |
| A | Allenton . . . | 0.19 | 800 | 0.08 | - - | 1,300 | 0.19 | 0.64 | 2,000 | 0.33 |
| B | Hartford . . . | 1.92 | 7,600 | 1.37[b] | 300 | 11,300 | 2.15 | 5.32 | 15,500 | 3.03 |
| C | Slinger . . . . | 0.45 | 1,300 | 0.15 | 600 | 2,800 | 0.48[c] | 2.32 | 4,400 | 0.81[c] |
| | Total | 2.56 | 9,700 | 1.60 | 900 | 15,400 | 2.82 | 8.28 | 21,900 | 4.17 |

[a] *See Map 85.*

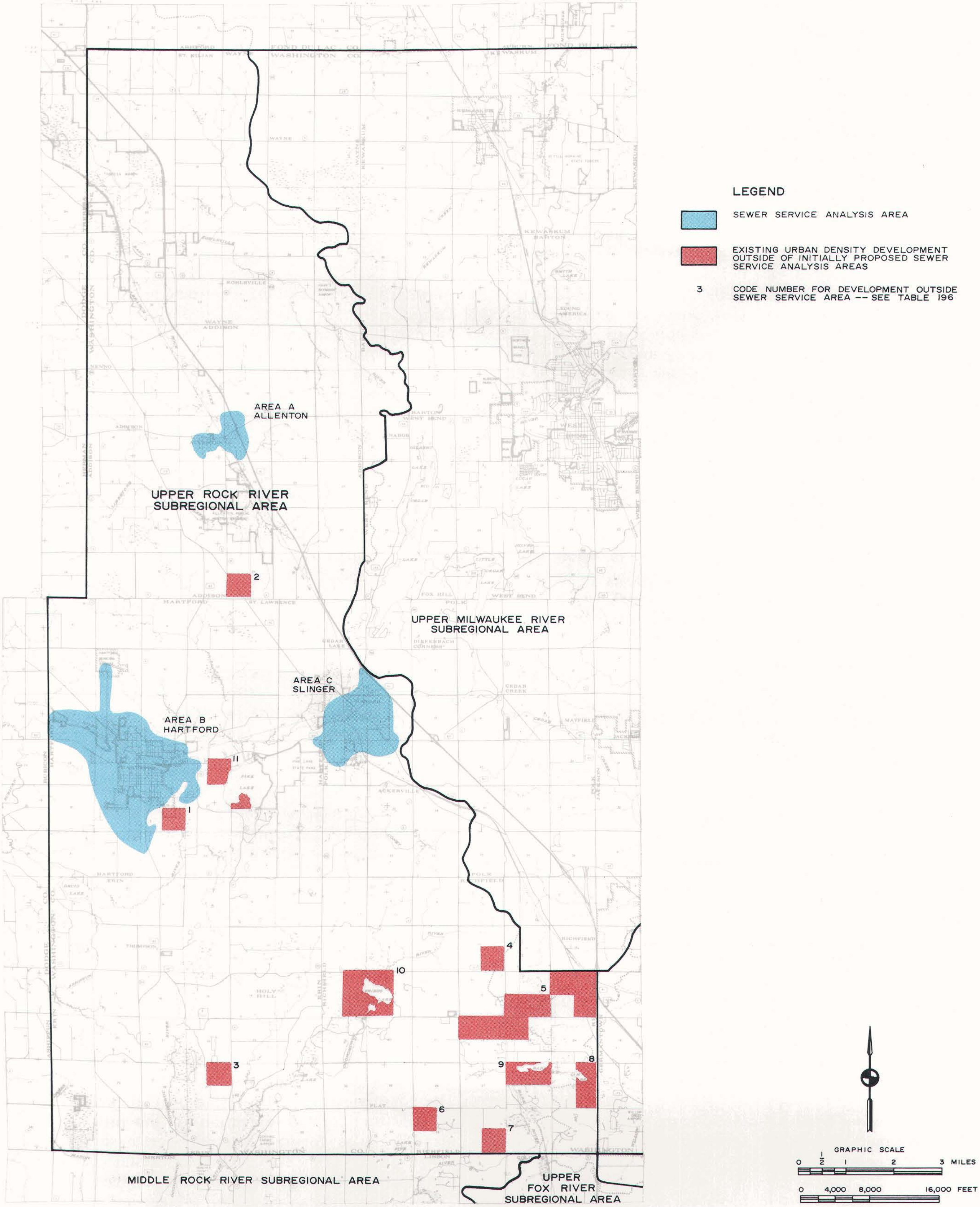
[b] *Includes an estimated wastewater contribution from Libby, McNeill and Libby, Inc.*

[c] *Includes an estimated wastewater contribution from the National Farmers Organization—Slinger Transfer Station.*

*Source: SEWRPC.*

Map 85

## SEWER SERVICE ANALYSIS AREAS: UPPER ROCK RIVER SUBREGIONAL AREA




Three urban sewer service areas were identified in the Upper Rock River subregional area: the City of Hartford and environs, the Village of Slinger and environs, and the unincorporated village of Allenton in the Town of Addison. By the year 2000, about 21,900 persons are expected to reside in these three sewer service areas, which will approximate 8.3 square miles. In 1975 there were about 25,200 persons residing in the Upper Rock River subregional area of which 9,700 were served by centralized sewer service and 15,500 by onsite sewage disposal systems.

*Source: SEWRPC.*

program. That modification involves the provision of a public sanitary sewerage system for the Pike Lake sewer service area. The 1990 regional sanitary sewerage system plan recommended that centralized sanitary sewer service be provided to existing urban development along the shoreline of Pike Lake and to the Pike Lake State Park, with treatment for sewage flows from these areas to be provided at the Hartford sewage treatment facility. Under the areawide water quality management planning effort, a detailed water quality management study was undertaken for Pike Lake. This study, which was conducted for the Commission by the Wisconsin Department of Natural Resources, has concluded that septic tanks contributed less than 10 percent of the phosphorus loading to Pike Lake and that, under the existing and proposed year 2000 development conditions, the total nutrient load to the lake is relatively low. Accordingly, the installation of centralized sanitary sewers to serve existing urban development and the Pike Lake State Park would probably not significantly improve water quality. Furthermore, this study indicated that, given a proper program of septic tank system inspection and maintenance over time, and given curtailed urban development in the lake subwatershed as called for in the adopted regional land use plan, it is unlikely that septic tank effluent would constitute a significant source of water pollution in the foreseeable future. Based upon this study, then, the areawide water quality management plan recommends that centralized sanitary sewer service not be extended to the Pike Lake area.

In 1978 the Village of Slinger completed facility planning for the construction of a new treatment facility planned to serve the Village of Slinger and environs. In addition, in 1973 the City of Hartford completed the construction of a new treatment plant to serve the City and environs. In view of these developments and of the plan proposal not to provide public sanitary sewers in the Pike Lake area, it was concluded that there were no potentially feasible alternatives for interconnection of public sanitary sewer service areas in the Upper Rock River subregional area. Accordingly, it was determined that the following sanitary sewerage system plans for the Upper Rock River subregional area should be prepared and evaluated:

1. A proposed plan for the Allenton sewer service area.
2. A proposed plan for the Slinger sewer service area.
3. Two alternative plans with regard to the type of treatment for the Hartford sewer service area.

Results of water quality simulations are presented under the previous section on the diffuse source control element recommendations for the Rock River watershed.

Sanitary sewerage system plans for each of the three sewer service areas that lie within the Upper Rock River subregional area are described in the following sections.

Proposed Plan—Allenton Subarea

In 1975 the wastewater treatment facility serving the Allenton Sanitary District No. 1 had an average hydraulic design capacity of 0.08 mgd, and provided a secondary level of waste treatment including auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Allenton sewer service area of about 0.19 mgd in 1985 and about 0.33 mgd in the year 2000. This year 2000 design flow is slightly lower than the estimated 1999 design flow of 0.36 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the East Branch of the Rock River, this facility will need to provide, in addition to the secondary level of waste treatment, either land application of plant effluent, or conventional advanced waste treatment for nitrification and phosphorus removal and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the East Branch of the Rock River. These recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the provision of phosphorus removal. That plan recommended secondary advanced waste treatment for nitrification and auxiliary waste treatment prior to discharge to the East Branch of the Rock River.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application is considered to be a viable alternative to providing secondary waste treatment with advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for effluent disinfection for treatment plants the size of the Allenton facility. The proposed plan of the areawide water quality management planning program is based on the alternative of treatment and effluent land application, but recognizes the need for more detailed local facilities planning to examine alternatives providing for surface water discharge as well as a land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. The recommended performance standards for the Allenton sewage treatment plant are set forth in Table 189, and the proposal is shown on Map 86.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities for the Allenton sewer service area is about $2,816,000. The estimated capital cost for constructing the necessary additional treatment facilities is $2,092,000, with an estimated average annual operation and maintenance cost of $78,000 over the design period 1975-2000 (see Table 190).

Table 189

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE ALLENTON SEWER SERVICE AREA: UPPER ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Allenton Sanitary District No. 1 | 0.19 | 0.33 | Allenton | 1,300 | 2,000 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] See Map 85.

[b] This treatment standard differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the East Branch of the Rock River.

Source: SEWRPC.

Table 190

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE ALLENTON SEWER SERVICE AREA: UPPER ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Allenton Sanitary District No. 1 | | | | | | | | |
| Facilities. . . . . . . . . . . | $1,964,000 | $78,000 | $1,509,000 | $1,234,000 | $2,743,000 | $ 95,000 | $78,000 | $173,000 |
| Land . . . . . . . . . . . . . | 128,000 | - - | 73,000 | - - | 73,000 | 5,000 | - - | 5,000 |
| Subtotal | $2,092,000 | $78,000 | $1,582,000 | $1,234,000 | $2,816,000 | $100,000 | $78,000 | $178,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $2,092,000 | $78,000 | $1,582,000 | $1,234,000 | $2,816,000 | $100,000 | $78,000 | $178,000 |

Source: SEWRPC.

Proposed Plan—Slinger Subarea

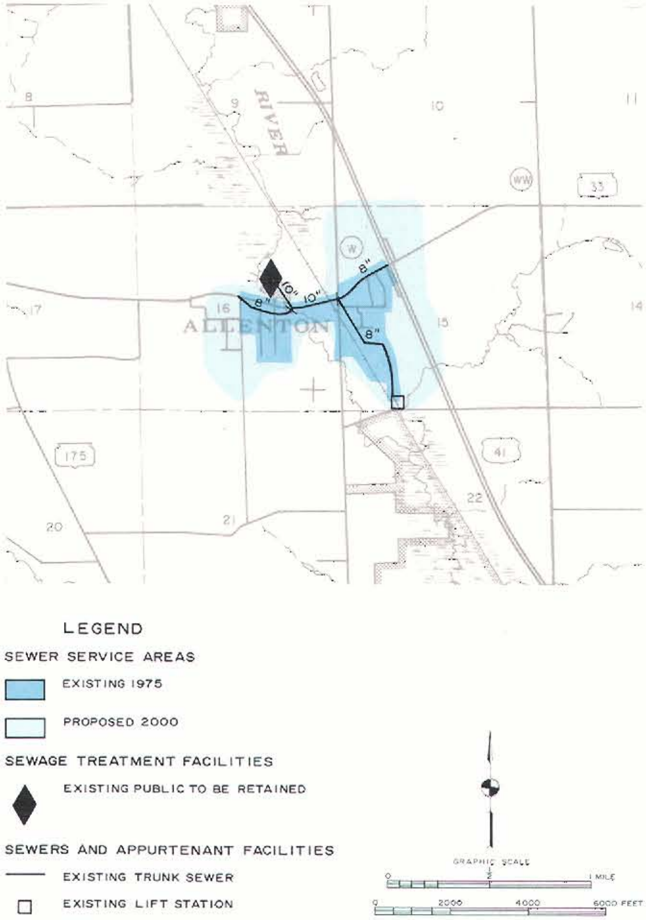
In 1975 the wastewater treatment facility serving the Village of Slinger had an average hydraulic design capacity of 0.15 mgd and provided a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection. It is anticipated that future growth will require an average hydraulic design capacity for the Slinger sewer service area of about 0.48 mgd in 1985 and about 0.81 mgd in the year 2000. This year 2000 design flow is somewhat higher than the estimated 1990 design flow of 0.67 mgd anticipated under the regional sanitary sewerage system plan.

In 1978 the Village of Slinger had completed facilities planning for construction of a new wastewater treatment plant. The proposed treatment plant will be located adjacent to the Rubicon River and about one-third mile northwest of the existing plant site. The proposed plant is designed to provide secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent disinfection, and is proposed to have an average hydraulic design capacity of about 0.80 mgd.

In order to meet established water use objectives for the Rubicon River, this facility will need to provide either a secondary level of waste treatment with auxiliary treatment for effluent disinfection followed by land application of the treatment plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an

Map 86

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE ALLENTON SEWER SERVICE AREA— UPPER ROCK RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan for the Allenton sewer service area proposes the expansion of the existing Allenton wastewater treatment plant to serve the year 2000 sewer service area. In order to meet the established water use objectives for the east branch of the Rock River, the plant will need to be upgraded to provide either land application of plant effluent following the current secondary level of treatment, or conventional advanced waste treatment for phosphorus removal and nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the east branch of the Rock River.

*Source: SEWRPC.*

effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Rubicon River. These recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the provision of phosphorus removal. That plan recommended the provision of secondary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent aeration and disinfection.

As previously noted, in 1978 the Village of Slinger completed local facility planning for a new wastewater treatment plant, with the detailed design work expected to be started late in 1978. Because of this completed facility plan recommendation providing for treatment facilities with a discharge to the Rubicon River, the decision to provide advanced waste treatment followed by discharge to surface waters has been treated as a committed local decision even though the areawide analysis indicated that, on a generalized basis, an effluent land application alternative may be less costly than providing the levels of treatment needed prior to discharge to surface waters. Future facilities planning efforts designed to evaluate the phosphorus reduction component of the proposed plan should further consider the land application alternative. The recommended performance standards for the Village of Slinger wastewater treatment plant are set forth in Table 191, and the proposal is shown on Map 87.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Slinger sewer service area is about $4,530,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $2,676,000, with an estimated average annual operation and maintenance cost of $164,200 (see Table 192).

Alternative Plans—Hartford Subarea

In 1975 the wastewater treatment facility serving the City of Hartford had an average hydraulic design capacity of 2.00 mgd, and provided a secondary level of waste treatment followed by advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to the Rubicon River. Presently, the treatment plant, which was construed in 1973, often achieves a significant reduction in ammonia-nitrogen even though it is not specifically designed for nitrification. It is anticipated that future growth will require an average hydraulic design capacity of about 2.15 mgd in 1985 and about 3.03 mgd in the year 2000. This year 2000 flow is nearly the same as the estimated 1990 design flow of 3.00 mgd anticipated under the regional sanitary sewerage system plan.

In order to meet established water use objectives for the Rubicon River, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of the plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Rubicon River. These recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the provision of phosphorus removal. The sanitary sewerage system plan recommended that the plant effluent have a total phosphorus

Table 191

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SLINGER SEWER SERVICE AREA: UPPER ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Slinger | 0.48 | 0.81 | Slinger | 2,800 | 4,400 | Secondary<br>Advanced<br><br><br>Auxiliary | Activated Sludge<br>Nitrification<br><br>Phosphorus Removal<br>Effluent Aeration<br><br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 85*

[b] *This treatment standard differs from the regional sanitary sewerage system plan, recommendations, which included the provision of secondary waste treatment followed by advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Rubicon River.*

*Source: SEWRPC.*

Table 192

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SLINGER SEWER SERVICE AREA: UPPER ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Slinger . . . . . . . | $2,608,000 | $164,000 | $1,971,000 | $2,514,000 | $4,485,000 | $125,000 | $159,000 | $284,000 |
| Trunk Sewer Village of Slinger . . . . . . . | 68,000 | 200 | 43,000 | 2,000 | 45,000 | 2,700 | 100 | 2,800 |
| Total | $2,676,000 | $164,200 | $2,014,000 | $2,516,000 | $4,530,000 | $127,700 | $159,100 | $286,800 |

*Source: SEWRPC.*

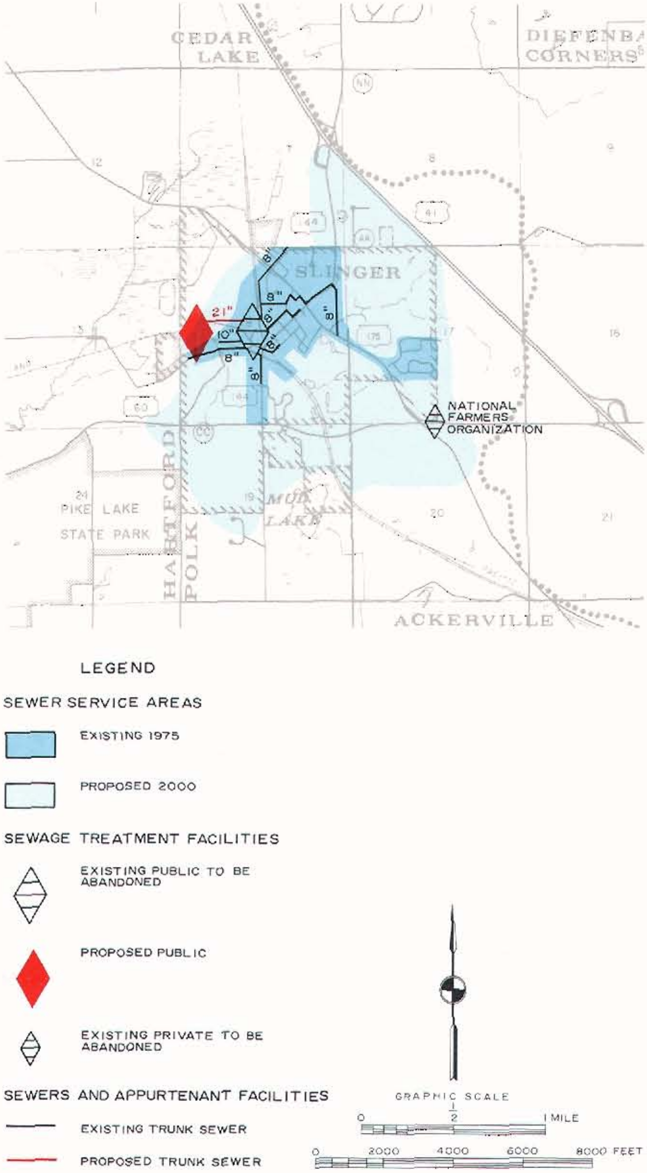
concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analysis described earlier in this chapter, the effluent land application alternative and the treatment and discharge alternative should be considered further in the alternative analyses for a plant the size of the Hartford facility. Accordingly, two treatment alternatives were considered for the Hartford wastewater treatment plant. The first alternative would provide for continued discharge of the Hartford wastewater treatment plant effluent to the Rubicon River following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the construction of a land application system for disposal of secondary treatment plant effluent at the Hartford wastewater treatment facility. The recommended wastewater treatment plant performance standards for both of the alternatives are set forth in Table 193, and two alternative plans are shown on Map 88.

The first alternative is based upon the provision of secondary waste treatment with conventional advanced waste treatment for nitrification and a high level of advanced waste treatment for phosphorus removal utilizing conventional chemical treatment for phosphorus removal, biological secondary treatment and nitrification, two-stage chemical clarification, multimedia filtration,

## Map 87

### PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SLINGER SEWER SERVICE AREA— UPPER ROCK RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the existing Slinger wastewater treatment plant be relocated to a new site and provide sufficient capacity to serve the year 2000 sewer service area. In order to meet the established water use objectives for the Rubicon River, it is proposed that the Slinger facility provide secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Rubicon River. Local facilities plans have been completed which propose the construction of a new treatment plant designed to provide secondary waste treatment with advanced waste treatment for nitrification and auxiliary waste treatment. Future planning efforts should consider the provision of the appropriate levels of phosphorus removal, and should evaluate the effluent land application alternative.

*Source: SEWRPC.*

and effluent chlorination prior to discharge to the Rubicon River. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment facilities included under Alternative Plan 1 for the Hartford sewer service area is about $9,731,000. The estimated capital cost for constructing the necessary additional treatment facilities is $3,966,000, with an estimated average annual operation and maintenance cost of $436,000 (see Table 194).

The second alternative treatment system is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural lands in the Towns of Hartford (Washington County) and Rubicon and Herman (both in Dodge County) were selected to receive the effluent from the Hartford wastewater treatment facility. These sites would require that the effluent be pumped about 5,000 feet. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Hartford sewer service area is about $10,425,000. The estimated capital cost for constructing the necessary additional treatment facilities is $8,646,000, with an estimated average annual operation and maintenance cost of $269,000 (see Table 194).

On an equivalent annual cost basis, including the cost for the sludge-related facilities required under Alternative Plan 1, Alternative Plan 2 would be about 8 percent less costly to implement than would Alternative Plan 1. However, there are other less tangible, but nevertheless real, factors which should be considered. Alternative Plan 1 could be more readily implemented since planning for most of the major components of the alternative is complete and since this alternative represents a continuation of existing practices with the added construction and operational requirements associated with the recommended expansion and upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 1,000 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management. Alternative Plan 2 also requires the construction of a major conveyance system to transport the treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 2.

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of the wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level

Table 193

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE HARTFORD SEWER SERVICE AREA: UPPER ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment System | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Hartford | 2.15 | 3.03 | Hartford | 11,300 | 15,500 | Secondary | Activated Sludge | $BOD_5$ Discharge: 15.0 mg/l |
| | | | | | | Advanced | Nitrification | Ammonia-Nitrogen Discharge: 1.5 mg/l |
| | | | | | | | Phosphorus Removal | Phosphorus Discharge: 0.1 mg/l[b] |
| | | | | | | Auxiliary | Effluent Aeration | Dissolved Oxygen in Effluent: 6.0 mg/l |
| | | | | | | | Disinfection | Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of Hartford | 2.15 | 3.03 | Hartford | 11,300 | 15,500 | Secondary | Activated Sludge | $BOD_5$ Discharge: 30.0 mg/l |
| | | | | | | Auxiliary | Disinfection | Fecal Coliform Concentration: 200/100 ml |
| | | | | | | Advanced | Land Application[b] | - - |

[a] *See Map 85.*

[b] *This treatment recommendation differs from regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Rubicon River.*

*Source: SEWRPC.*

of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, based on the environmental impacts and ease of implementation, Alternative Plan 1—the treatment and surface water discharge alternative—is recommended.

Private Wastewater Treatment Plants

There are three known private wastewater treatment facilities in the Upper Rock River subregional area which in general serve isolated enclaves of urban land uses and treat wastes which can be accepted in public sanitary sewerage systems. These facilities currently discharge relatively minor amounts of treated wastes to the streams and groundwater in the Upper Rock River subregional area. These three facilities serve Libby, McNeill and Libby Canning Company in the City of Hartford, the National Farmers Organization—Slinger Transfer Station in the Town of Polk, and Pike Lake State Park in the Town of Hartford. The Libby, McNeill and Libby Canning Company presently provides pretreatment prior to final treatment at the Hartford treatment plant. This treatment system is expected to continue during the plan implementation period. The National Farmers Organization—Slinger Transfer Station lies within the year 2000 proposed Slinger service area and hence would be abandoned upon implementation of the proposed sewerage system plan. The remaining facility, that serving the Pike Lake State Park, is located outside of the proposed year 2000 sewer service area and as such should be upgraded and expanded to meet year 2000 needs. It is proposed that this facility continue to utilize land application of secondary effluent. The recommended performance standards for the Pike Lake State Park treatment facility are shown in Table 195.

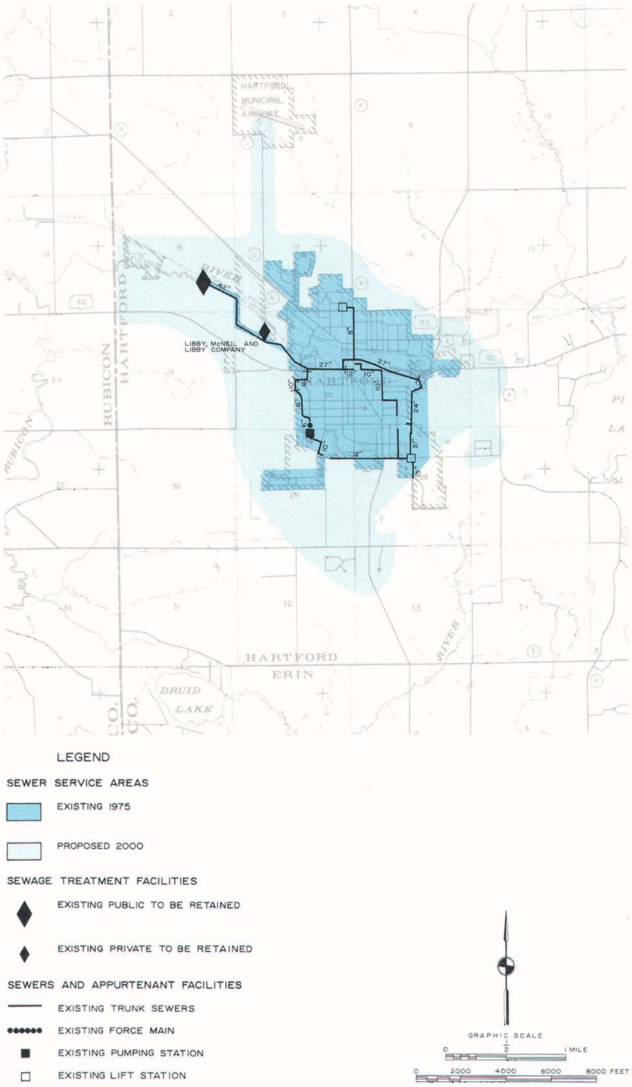
The total present worth over a 50-year analysis period of construction and operation of the private wastewater treatment facilities for the Upper Rock River subregional area is about $845,000. The estimated capital cost for constructing the necessary additional facilities is $430,000, with an estimated average annual operation and maintenance cost of $33,000 over the design period 1975-2000.

Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are 11 enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area as shown on Map 85. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are

Map 88

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE HARTFORD SEWER SERVICE AREA—UPPER ROCK RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the existing Hartford treatment plant be upgraded to serve the year 2000 sewer service area. In order to meet the established water use objectives for the Rubicon River, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of the plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Rubicon River. Both the surface water discharge and effluent land application alternatives were considered. The alternative of providing advanced waste treatment prior to discharge to the surface water, more closely reflects recent local planning and construction efforts.

*Source: SEWRPC.*

listed in Table 196. In a general analysis described earlier in this chapter, the cost of providing public sewerage service to these enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based on the results of that analysis, it was concluded that wastewater treatment for these 11 enclaves of urban development should be provided in one of two ways.

For the remaining urban enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. These areas, which should consider alternative methods of onsite waste disposal, and an intensive inspection and maintenance program for conventional systems, as well as the possibility of connections to the public sanitary sewer service area, are the City of of Hartford, Bark Lake, Friess Lake, and Pike Lake in Washington County. In general, areas in this category have soil conditions and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

For the remaining urban enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. These areas, which should consider alternative methods of onsite waste disposal as well as the possibility of connections to the public sanitary sewer service area, are the City of of Hartford, Bark Lake, Friess Lake, and Pike Lake in Washington County. In general, areas in this category have soil conditions and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

Sanitary Sewer System Flow Relief Devices

In 1975 there were no known sanitary sewer system flow relief devices in the Upper Rock River subregional area.

Other Known Point Sources of Wastewater

There are a total of four known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Upper Rock River subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of five-day biochemical oxygen demand ($BOD_5$), ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar surface water bodies. Thus, in most cases no further treatment recommendations were advanced for these other point sources with regard to these constituents. However, it is recommended

Table 194

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE HARTFORD SEWER SERVICE AREA: UPPER ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plant City of Hartford[a] | $3,966,000 | $436,000 | $2,999,000 | $6,732,000 | $ 9,731,000 | $190,000 | $427,000 | $617,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $3,966,000 | $436,000 | $2,999,000 | $6,732,000 | $ 9,731,000 | $190,000 | $427,000 | $617,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant City of Hartford | | | | | | | | |
| Facilities | $7,737,000 | $269,000 | $5,604,000 | $4,300,000 | $ 9,904,000 | $356,000 | $273,000 | $629,000 |
| Land | 909,000 | - - | 521,000 | - - | 521,000 | 33,000 | - - | 33,000 |
| Subtotal | $8,646,000 | $269,000 | $6,125,000 | $4,300,000 | $10,425,000 | $389,000 | $273,000 | $662,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $8,646,000 | $269,000 | $6,125,000 | $4,300,000 | $10,425,000 | $389,000 | $273,000 | $662,000 |

[a]*This alternative does not include the cost of additional facilities related to the increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the added sludge-handling and -disposal facilities is $1,526,000. The estimated capital cost of construction of the added sludge-related is $990,000, with an estimated average annual operation and maintenance cost of $53,000 over the design period 1975-2000.*

*Source: SEWRPC.*

Table 195

WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE UPPER ROCK RIVER SUBREGIONAL AREA

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| Pike Lake State Park | Town of Hartford | Recreational | Sanitary | Soil Absorption | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |

*Source: SEWRPC.*

Table 196

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE UPPER ROCK RIVER SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population | | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | | 1975 | 2000 | |
| | Washington County | | | |
| 1 | City of Hartford | 118 | 118 | - - |
| 2 | Town of Addison-St. Lawrence | 254 | 229 | 2.6 |
| 3 | Town of Erin—Section 27 | 128 | 167 | 5.1 |
| 4 | Town of Richfield—Section 10 | 73 | 256 | 1.5 |
| 5 | Town of Richfield—Sections 13, 14, 22, and 23 | 2,155 | 1,959 | 0.3 |
| 6 | Town of Richfield—Section 33 | 229 | 322 | 2.6 |
| 7 | Town of Richfield—Section 34 | 208 | 233 | 2.3 |
| 8 | Amy Bell Lake | 396 | 434 | 0.4 |
| 9 | Bark Lake | 427 | 361 | 1.0 |
| 10 | Friess Lake | 580 | 393 | 4.0 |
| 11 | Pike Lake | 422 | 342 | 1.5 |
| Total | | 4,990 | 4,814 | - - |

[a] *See Map 85.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

that the remaining point sources in general reduce discharge temperatures to 89°F or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 197.

The table indicates there are no effluent characteristics reported that require treatment except for W. B. Place & Company, which is recommended to be connected to the City of Hartford sanitary sewer system. The cost of the treatment and operation and maintenance associated with this is included in the cost of the Hartford public wastewater treatment facility discussed earlier in this section. No additional costs have been estimated under the areawide water quality management planning program.

MIDDLE ROCK RIVER SUBREGIONAL AREA

The Middle Rock River subregional area consists of all that part of the Rock River watershed in Waukesha County. This portion of the Rock River watershed is comprised of all or portions of several subwatersheds, including the Oconomowoc River subwatershed, the Ashippun River subwatershed, the Bark River subwatershed, and the Scuppernong Creek subwatershed. A large portion of the Middle Rock River subregional area consists of existing and proposed Kettle Moraine State Forest lands. To the north of the state forest lands lies the rapidly urbanizing inland lakes area of western Waukesha County. Major concentrations of urban development are found in the Cities of Delafield and Oconomowoc and the Villages of Chenequa, Hartland, Dousman, Lac La Belle, Nashotah, and Wales. Urban development contiguous to the Village of Lac La Belle in the Town of Ixonia in Jefferson County, outside of the Region, has also been included in the Middle Rock River subregional area for sewerage system planning purposes.

**Table 197**

**REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION—UPPER ROCK RIVER SUBREGIONAL AREA: 1975**

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| W. B. Place & Company, Inc. . . | City of Hartford | 0.001 | Rubicon River | Suspended Solids, Phosphorus, Temperature |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or reports provided under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Centralized sanitary sewer service in the Middle Rock River subregional area was provided by three systems in 1975: those operated by the City of Oconomowoc and the Villages of Hartland and Dousman. The service areas of these three systems together comprised about 4.4 square miles and served an estimated population of 16,500 persons. In 1975 there were about 25,000 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the three existing systems are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Sewer Service Analysis Areas

A total of 13 sewer service analysis areas may be identified within the Middle Rock River subregional area (see Table 198). These 13 sewer service analysis areas are shown on Map 89 and may be described as follows:

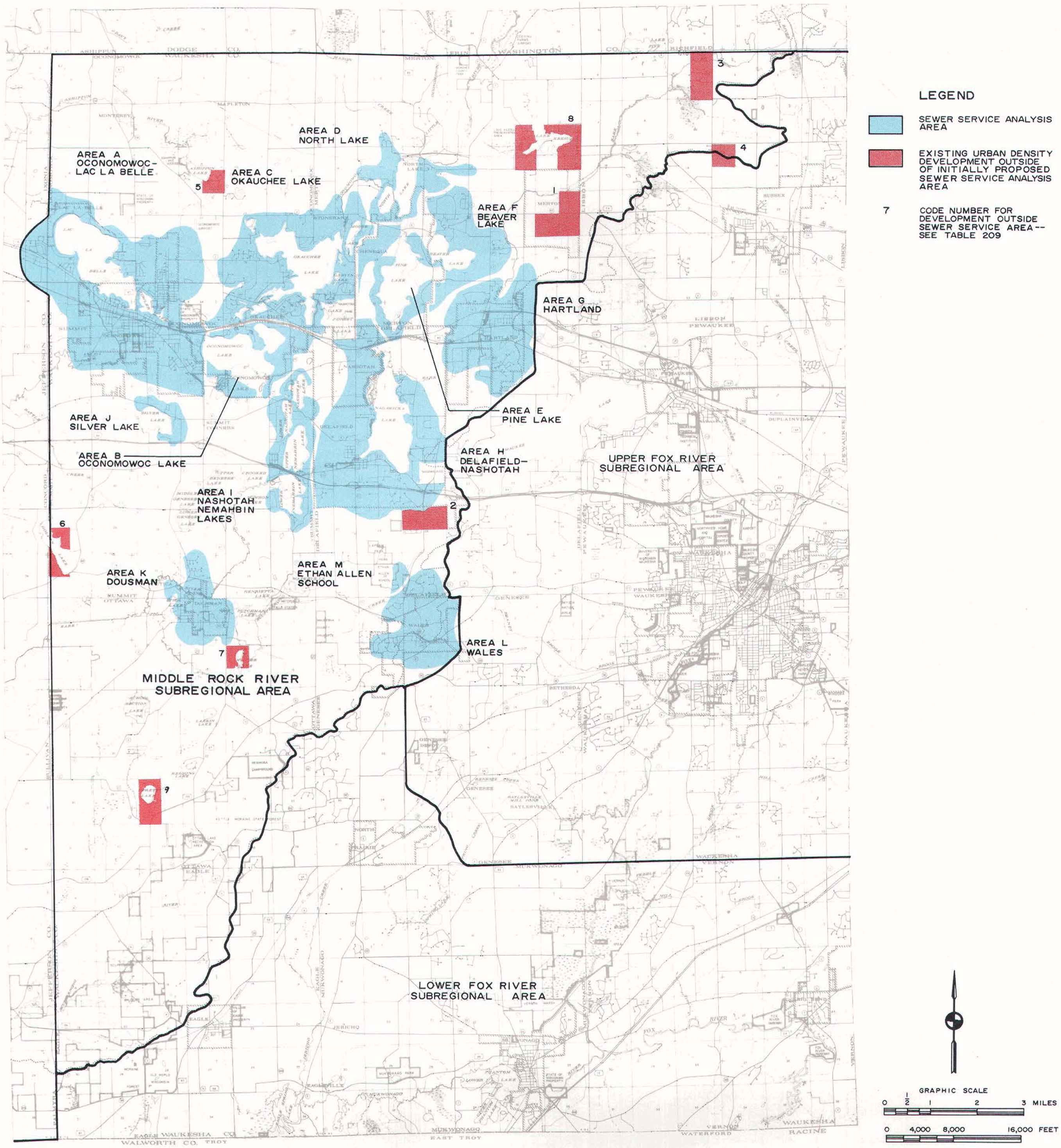
1. Area A—This area consists of the City of Oconomowoc, the Village of Lac La Belle, and contiguous urban development in the Towns of Oconomowoc and Summit in Waukesha County and in the Town of Ixonia outside of the Region in Jefferson County. In 1975 sanitary sewer service was provided in this area to about 2.7 square miles, having a total resident population of about 11,100 persons. The total area anticipated to be served by the year 2000 approximates 9.6 square miles, with a projected resident population of about 21,300 persons. This is essentially the same planned population as the 21,000 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Oconomowoc-Lac La Belle" sewer service area in the ensuing discussion.

2. Area B—This area consists of the Village of Oconomowoc Lake, which encompasses all of the urban development along the shoreline of Oconomowoc Lake, and contiguous urban development in the Town of Summit. About 400 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.5 square miles, with a projected resident population of about 700 persons. This represents a modest increase in planned population from the 600 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Oconomowoc Lake" sewer service area in the ensuing discussion.

3. Area C—This area consists of the contiguous urban development along the shoreline of Okauchee Lake in the Towns of Oconomowoc and Merton. About 4,500 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served

## Map 89

## SEWER SERVICE ANALYSIS AREAS: MIDDLE ROCK RIVER SUBREGIONAL AREA




A total of 13 individual sewer service analysis areas were identified within the Middle Rock River subregional area. These 13 areas include the Cities of Delafield and Oconomowoc and environs and existing urban development located in the small villages and unincorporated communities found along the shorelines of the many lakes in this portion of the Rock River watershed. By the year 2000, about 57,400 persons are expected to reside in these 13 sewer service areas, which will approximate 37.0 square miles. In 1975 there were about 41,500 persons residing in the Middle Rock River subregional area, of which 16,500 were served by centralized sewer service and 25,000 by onsite sewage disposal systems.

*Source: SEWRPC.*

Table 198

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE MIDDLE ROCK RIVER SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] Letter | Name | Existing 1975 Area Served (square miles) | Existing 1975 Population Served | Existing 1975 Average Hydraulic Loading (mgd) | Existing 1975 Unserved Population Residing in the Proposed 2000 Service Area | Planned 1985 Population Served | Planned 1985 Design Hydraulic Loading (mgd) | Planned 2000 Area Served (square miles) | Planned 2000 Population Served | Planned 2000 Design Hydraulic Loading (mgd) |
|---|---|---|---|---|---|---|---|---|---|---|
| A | Oconomowoc-Lac La Belle . | 2.74 | 11,100 | 1.90 | 1,600 | 16,400[b] | 3.01 | 9.58 | 21,300[b] | 4.04 |
| B | Oconomowoc Lake . . . . . . | 0.00 | 0 | 0.00 | 400 | 600 | 0.13 | 1.50 | 700 | 0.15 |
| C | Okauchee Lake . . . . . . . . | 0.00 | 0 | 0.00 | 4,500 | 4,900 | 1.03 | 4.84 | 6,200 | 1.30 |
| D | North Lake . . . . . . . . . . | 0.00 | 0 | 0.00 | 700 | 700 | 0.15 | 1.23 | 800 | 0.17 |
| E | Pine Lake . . . . . . . . . . . | 0.00 | 0 | 0.00 | 400 | 900 | 0.19 | 1.21 | 1,400 | 0.29 |
| F | Beaver Lake . . . . . . . . . . | 0.00 | 0 | 0.00 | 1,000 | 1,300 | 0.27 | 2.45 | 2,200 | 0.46 |
| G | Hartland . . . . . . . . . . . . | 1.25 | 4,400 | 0.42 | 200 | 6,100 | 0.80[c] | 4.16 | 7,100 | 1.01[c] |
| H | Delafield-Nashotah . . . . . . | 0.00 | 0 | 0.00 | 3,700 | 4,500 | 0.98[d] | 5.58 | 9,400 | 2.00[d] |
| I | Nashotah-Nemahbin Lakes. . | 0.00 | 0 | 0.00 | 1,300 | 1,500 | 0.32 | 1.33 | 1,700 | 0.36 |
| J | Silver Lake. . . . . . . . . . . | 0.00 | 0 | 0.00 | 400 | 400 | 0.08 | 0.47 | 600 | 0.11 |
| K | Dousman. . . . . . . . . . . . | 0.45 | 1,000 | 0.11 | 200 | 1,500 | 0.22 | 1.71 | 2,100 | 0.34 |
| L | Wales . . . . . . . . . . . . . . | 0.00 | 0 | 0.00 | 1,400 | 2,500 | 0.53 | 2.77 | 3,100 | 0.65 |
| M | Ethan Allen School[e] . . . . . | - - | - - | - - | - - | 600 | 0.13 | 0.16 | 800 | 0.17 |
| | Total | 4.44 | 16,500 | 2.43 | 15,800 | 41,900 | 7.84 | 36.99 | 57,400 | 11.05 |

[a] *See Map 89.*

[b] *Includes an estimated 700 persons living in the Town of Ixonia Sanitary District No. 2 in Jefferson County.*

[c] *Includes an estimated wastewater contribution from the Gigas Hillside Apartments.*

[d] *Includes an estimated wastewater contribution from the St. John's Military Academy.*

[e] *The Ethan Allen School for Boys service area is presently served by a private wastewater treatment facility.*

*Source: SEWRPC.*

with centralized sanitary sewer service by the year 2000 approximates 4.8 square miles, with a projected resident population of about 6,200 persons. This represents a substantial increase in planned population from the 4,400 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Okauchee Lake" sewer service area in the ensuing discussion.

4. Area D—This area consists of the contiguous urban development along the shoreline of North Lake in the Village of Chenequa and the Town of Merton. About 700 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.2 square miles, with a projected resident population of about 800 persons. This represents a decrease in planned population from the 1,100 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "North Lake" sewer service area in the ensuing discussion.

5. Area E—This area includes all of the estate-type residential development along the shoreline of Pine Lake in the Village of Chenequa. About 400 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.2 square miles, with a projected resident population of about 1,400 persons. This represents a substantial increase in planned population from the 400 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This area has been included as a sewer service area for sewerage system planning analysis purposes, even though it presently has an extremely low-density character, because it lies within a larger area for which centralized sanitary sewer service will likely be required. Sound long-range system planning requires, therefore, that this area be included in the alternative plans even though it may be unnecessary to provide for the local trunk sewers to serve the Pine Lake development within the 25-year plan design period. This subarea is referenced as the "Pine Lake" sewer service area in the ensuing discussion.

6. Area F—This area consists of the urban development along and adjacent to the shoreline of Beaver Lake in the Village of Chenequa and the Town of Merton. About 1,000 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 2.5 square miles, with a projected resident population of about 2,200 persons. This represents no change from the forecast for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Beaver Lake" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Hartland and contiguous urban development in the Towns of Merton and Delafield. In 1975 sanitary sewer service was provided in this area to about 1.3 square miles, having a total resident population of about 4,400 persons. The total area anticipated to be served by the year 2000 approximates 4.2 square miles, with a projected resident population of about 7,100 persons. This represents an increase from the 6,400 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Hartland" sewer service area in the ensuing discussion.

8. Area H—This area consists of the City of Delafield and the Village of Nashotah, which together encompass Nagawicka Lake. About 3,700 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 5.6 square miles, with a projected resident population of about 9,400 persons. This represents a substantial increase from the 7,300 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Delafield-Nashotah" sewer service area in the ensuing discussion.

9. Area I—This area consists of the urban development along the shorelines of Upper and Lower Nashotah Lakes and Upper and Lower Nemahbin Lakes in the Town of Summit. About 1,300 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 1.3 square miles, with a projected resident population of about 1,700 persons. This represents a slight increase from the 1,500 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Nashotah-Nemahbin Lakes" sewer service area in the ensuing discussion.

10. Area J—This area consists of urban development along the shoreline of Silver Lake in the Town of Summit. About 400 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 0.5 square mile, with a projected resident population of about 600 persons. This represents no change from the forecast for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Silver Lake" sewer service area in the ensuing discussion.

11. Area K—This area includes the Village of Dousman and environs. In 1975 sanitary sewer service was provided in this area to about 0.5 square mile, having a total resident population of about 1,000 persons. The total area anticipated to be served by the year 2000 approximates 1.7 square miles, with a projected resident population of about 2,100 persons. This represents no change from the forecast for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Dousman" sewer service area in the ensuing discussion.

12. Area L—This area consists of the Village of Wales and environs. About 1,400 persons resided in this area in 1975, but no sanitary sewer service was provided. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 2.8 square miles, with a projected resident population of about 3,100 persons. This represents a substantial increase from the 1,100 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Wales" sewer service area in the ensuing discussion.

13. Area M—This area consists of the Ethan Allen School (a minimum security facility for male juveniles) in the Town of Delafield. While the sanitary sewerage system operated by the Wisconsin Department of Health and Social Services to serve this institution is not, strictly speaking, a public centralized sanitary sewerage system, the service area has all the characteristics of a small urban village, and the sewage treatment facility is as large as some facilities serving typical villages throughout the Region. For this reason, the Ethan Allen School has been considered as a separate sewer service area for regional sewerage system planning purposes. The institution is expected to accommodate an equivalent population of about 800 persons in the year 2000. This subarea is referenced as the "Ethan Allen School" sewer service area in the ensuing discussion.

The regional sanitary sewerage system plan had initially designated the Village of Merton a sewer service area. However, based upon further analysis and subsequent public comment, that area was deleted from the areas recommended to be provided with a public sanitary sewer system. The Village of Merton was not specifically included in the area recommended to be provided with public sanitary sewers under the areawide water quality management planning program. However, the recommendations of the regional sanitary sewerage system plan, which proposed that consideration be given to either providing a separate treatment plant or conveyance of wastewater to the proposed Delafield-Hartland areawide treatment facility when it is determined that public sewers are necessary to serve the Merton area, are incorporated into the areawide planning program.

Formulation of Alternatives

As noted earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system plan to formulate and evaluate alternative public sanitary sewerage system plans. First, the potential for interconnection of community sanitary sewerage systems was evaluated. In the Middle Rock River subregional area, all but three of the 13 sewer service areas were noted to be essentially contiguous. It was assumed with respect to the other 10 sewer service areas, therefore, that contiguity would require detailed economic analyses of interconnection potential. In addition, one other interconnection—Merton to Hartland—was found to be potentially feasible. However, as previously noted, the recommendation to provide public sewer service to the Village of Merton was ultimately revised in the regional sanitary sewerage system plan, and that sewer service area was not included as sewered in the regional sanitary sewerage system plan or this subsequent plan. Detailed analyses of three alternative plans were made for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, Pine Lake, Silver Lake, North Lake, Beaver Lake, Hartland, Delafield-Nashotah and Nashotah-Nemahbin Lakes sewer service areas. These three alternatives provided for the construction of wastewater treatment facilities for each sewer service area, for construction of two centralized wastewater treatment facilities (at Oconomowoc and Delafield), which were ultimately recommended to serve the areas, and for construction of one centralized wastewater treatment facility. A detailed discussion of these alternative proposals can be found in Chapter XI of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.

Analyses were conducted of estimated existing and future water quality conditions in the Bark River, Oconomowoc River, and Scuppernong Creek. The water quality in the Oconomowoc River and Scuppernong Creek was not specifically simulated utilizing the water quality model. However, both existing and future water quality conditions were considered utilizing sample data, model results from similar watershed, and related calculations. Water quality was simulated for the Bark River utilizing the computer simulation model. The analyses indicate that it will generally be necessary to provide a higher level of wastewater treatment with regard to phosphorus removal in the Middle Rock River subregional area than had been recommended under the regional sanitary sewerage system plan. These modified recommended performance standards are not expected to change the recommendations with regard to the number and location of public wastewater treatment facilities, since the recommendations of the regional sanitary sewerage system plan have been generally verified by subsequent local facilities planning for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, Pine Lake, Silver Lake, North Lake, Beaver Lake, Hartland, Delafield-Nashotah, Nashotah-Nemahbin Lakes, and Dousman sewer service areas. The regional sanitary sewerage system plan recommended that the Oconomowoc treatment facility serve the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, Pine Lake, Silver Lake, North Lake, and Beaver Lake sewer service areas, and that the Delafield-Hartland Water Pollution Control Commission plant serve the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas. Subsequent facilities planning for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, Pine Lake, Silver Lake, North Lake, and Beaver Lake sewer service areas has been completed, with the recently completed Oconomowoc wastewater treatment plant designed considering ultimate expansion to provide sewer service to a potential service area that will include all of the areas recommended to be tributary to that plant in the regional sanitary sewerage system plan. In addition, a local facility planning report has been completed for the major trunk sewer facilities needed to convey wastewater from the recommended sewer service areas to the Oconomowoc plant. A facility plan has also been completed by the Delafield-Hartland Water Pollution Control Commission for wastewater treatment and conveyance facilities to serve the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas. Construction of the areawide facility to serve these areas is expected to begin in 1978. In addition, the Village of Dousman has completed facilities planning for wastewater treatment facility upgrading and expansion. Because of these completed implementation actions, it was determined that further analysis of the alternatives examined in the regional sanitary sewerage system plan with regard to the number and location of treatment facilities in the Middle Rock River subregional area would not be needed, and the recommendations of that plan are incorporated into the areawide plan. Alternative treatment methods, however, have been considered, as reported in the following analyses, for the Oconomowoc and Delafield-Hartland treatment facilities.

Connection of the Ethan Allan School sewer service area to the Wales sewer service area for wastewater treatment plant purposes was not evaluated, since the facility serving the Ethan Allan School was recently rebuilt and has adequate capacity to provide treatment for the estimated year 2000 hydraulic loading from its tributary sewer service area. In addition, the existing facility utilizes soil absorption for plant effluent disposal, which is considered compatible with water use objectives in Scuppernong Creek, provided the system is operating properly. However, the continued operation of the Ethan Allan School soil absorption system should be carefully monitored. Should future investigation conclude that soil absorption as a means of effluent disposal is no longer feasible, the interconnection of the Ethan Allan School and Wales sewer service areas for wastewater treatment purposes should then be evaluated.

Accordingly, it was determined that the following sanitary sewerage system plans for the 13 sewer service areas that lie within the Middle Rock River subregional area should be prepared and evaluated:

1. Two alternative plans—only with regard to type of treatment—for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, Pine Lake, Silver Lake, North Lake, and Beaver Lake sewer service areas.

2. Two alternative plans—only with regard to type of treatment—for the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas.

3. A proposed plan for the Dousman sewer service area.

4. A proposed plan for the Wales sewer service area.

5. A proposed plan for the Ethan Allan School sewer service area.

The recommended plan for sanitary sewerage in the Middle Rock River subregional area, as developed under the regional sanitary sewerage system plan, is incorporated, with certain modifications indicated as desirable by subsequent system and facilities planning efforts, as an integral part of the areawide water quality management plan recommendations. Results of water quality simulations are presented under the previous section on the diffuse source control element recommendations for the Rock River watershed.

Sanitary sewerage system plans for each of the 13 sewer service areas that lie in the Middle Rock River subregional area are described in the following sections.

Alternative Plans—Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake Subareas

The recommended plan for the Middle Rock River subregional area proposes that the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake sewer service areas be served by the Oconomowoc wastewater treatment facility.

In 1975 the wastewater treatment facility serving the City of Oconomowoc had an average hydraulic design capacity of about 1.50 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth and the inclusion of the above sewer service areas will require an average hydraulic design capacity of about 4.86 mgd in 1985 and about 6.52 mgd in the year 2000. This year 2000 design flow is slightly higher than the estimated 1990 design flow of 6.2 mgd anticipated under the regional sanitary sewerage system plan.

As previously noted, the City of Oconomowoc recently completed upgrading and expansion of its treatment plant. The upgraded plant is designed to provide secondary waste treatment followed by tertiary treatment and auxiliary waste treatment for effluent disinfection, and to have an average hydraulic design capacity of 4.0 mgd.

In order to meet established water use objectives for the Oconomowoc River, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Oconomowoc River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that the Oconomowoc plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analyses described earlier in this chapter, the effluent land application alternative and treatment and discharge alternative should be considered further for a plant the size of the Oconomowoc facility. Accordingly, two treatment alternatives were considered for this plant. The first alternative would provide for continued discharge of the Oconomowoc wastewater treatment plant effluent to the Oconomowoc River following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the provision of a land application system for disposal of secondary treatment plant effluent from the Oconomowoc wastewater treatment facility. The recommended wastewater treatment plant performance standards for both of the alternatives are set forth in Table 199, and the two proposals are shown on Map 90.

The first alternative is based upon the provision of secondary waste treatment followed by advanced waste treatment for ammonia-nitrogen and phosphorus removal utilizing conventional chemical treatment for phosphorus removal, biological secondary treatment and nitrification, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to the Oconomowoc River. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake sewer service areas is about $23,305,000. The estimated capital cost for constructing the necessary additional and conveyance treatment facilities is $15,049,000, with an estimated average annual operation and maintenance cost of $794,000 (see Table 200).

The second alternative treatment system is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by

Table 199

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE OCONOMOWOC-LAC LA BELLE, OCONOMOWOC LAKE, OKAUCHEE LAKE, NORTH LAKE, PINE LAKE, BEAVER LAKE, AND SILVER LAKE SEWER SERVICE AREAS: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Oconomowoc | 4.86 | 6.52 | Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake | 25,900 | 33,700 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Effluent Aeration<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of Oconomowoc | 4.86 | 6.52 | Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake | 25,900 | 33,700 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] *See Map 89.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Oconomowoc River.*

*Source: SEWRPC.*

land application. For areawide systems level analysis purposes, rural lands in the Towns of Summit in Waukesha County and Concord in Jefferson County were selected to receive the effluent from the Oconomowoc wastewater treatment facility. These sites would require that the effluent be pumped about 1,500 feet.

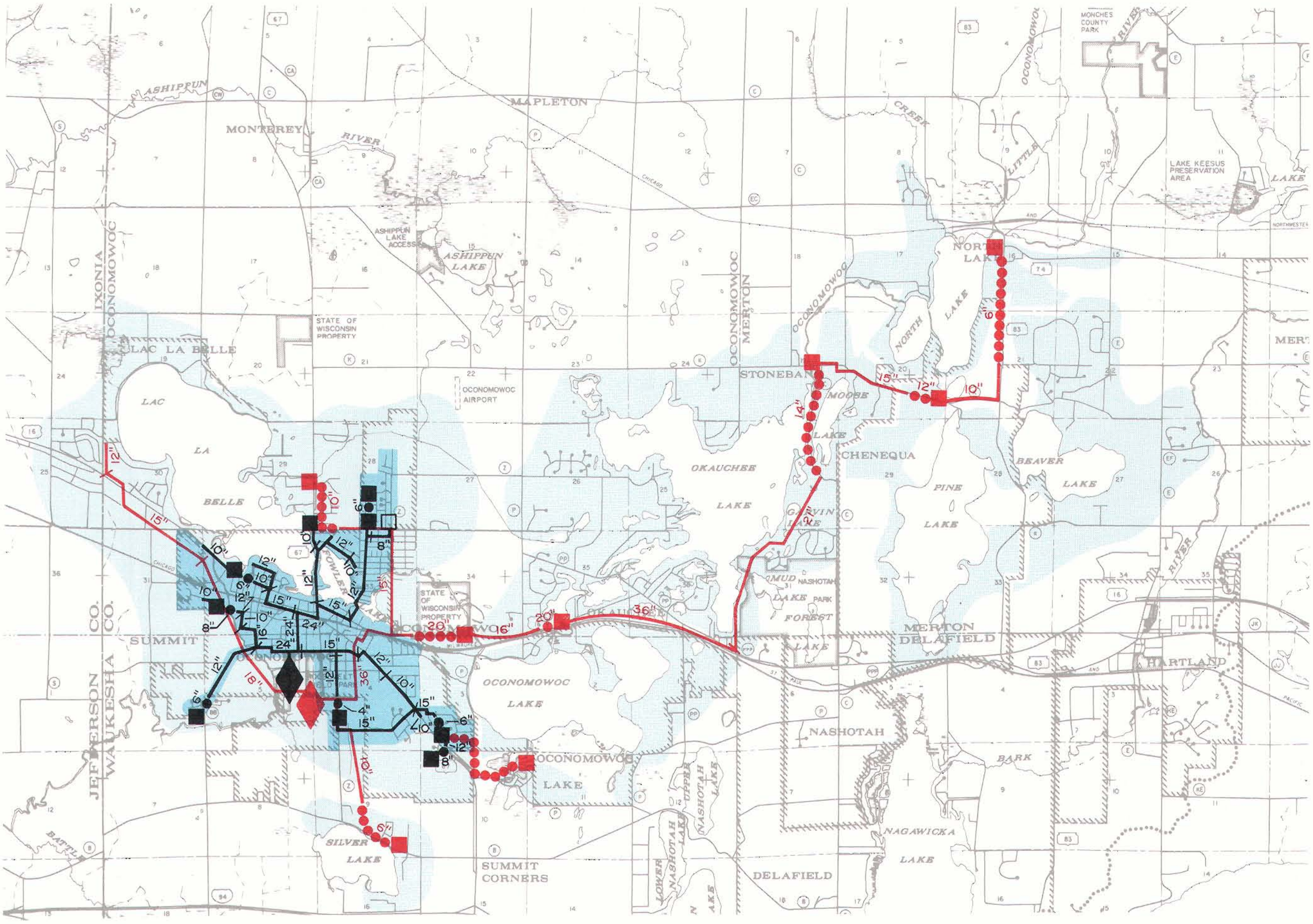
The total present worth over a 50-year analysis period of construction and operation of the recommended treatment and conveyance facilities included under Alternative Plan 2 for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake sewer service areas is about $23,612,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $23,966,000, with an estimated average annual operation and maintenance cost of $479,000 (see Table 200).

On an equivalent annual cost basis, including the cost of the sludge-related facilities required under Alternative Plan 1, Alternative Plan 2 would be about 5 percent less costly to implement than would Alternative Plan 1. However, there are other less tangible, but nevertheless real, factors that should be considered. Alternative Plan 1 could be more readily implemented since it represents a continuation of existing practices with the added construction and operational requirements associated with the recommended expansion and upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 2,000 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management. Alternative Plan 2 also requires the construction of a major conveyance system to transport treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1.

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of the wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, based on the environmental impacts and ease of implementation, Alternative Plan 1—the treatment and surface water discharge alternative—is recommended.

## Map 90

### ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE OCONOMOWOC-LAC LA BELLE, OCONOMOWOC LAKE, OKAUCHEE LAKE, NORTH LAKE, PINE LAKE, BEAVER LAKE, AND SILVER LAKE SEWER SERVICE AREAS—MIDDLE ROCK RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

- EXISTING 1975
- PROPOSED 2000

SEWAGE TREATMENT FACILITIES

- EXISTING PUBLIC TO BE RETAINED
- PROPOSED PUBLIC

SEWERS AND APPURTENANT FACILITIES

- EXISTING TRUNK SEWER
- PROPOSED TRUNK SEWER
- EXISTING FORCE MAIN
- PROPOSED FORCE MAIN
- EXISTING LIFT STATION
- EXISTING PUMPING STATION
- PROPOSED PUMPING STATION

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

Both alternative sanitary sewerage system plans for the Oconomowoc-Lac La Belle, Oconomowoc Lake, Okauchee Lake, North Lake, Pine Lake, Beaver Lake, and Silver Lake subareas of the Rock River watershed would concentrate treatment of sewage at one treatment facility. This combination of subareas closely reflects local planning efforts to establish one centralized treatment facility to serve the Oconomowoc River communities. In order to meet the established water use objectives of the Oconomowoc River, the City of Oconomowoc wastewater treatment facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection and land application of plant effluent, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Oconomowoc River. Both treatment alternatives were considered. The treatment and discharge alternative is proposed under the areawide water quality management plan, even though it is estimated slightly more costly for the systems level analysis, because it more closely reflects local planning efforts, and would not involve the potential implementation problems associated with the land application alternative.

*Source: SEWRPC.*

## Table 200

## DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE OCONOMOWOC-LAC LA BELLE, OCONOMOWOC LAKE, OKAUCHEE LAKE, NORTH LAKE, PINE LAKE, BEAVER LAKE, AND SILVER LAKE SEWER SERVICE AREAS: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Oconomowoc . . . . . . . . | $9,221,000 | $752,000 | $ 6,971,000 | $11,118,000 | $18,089,000 | $442,000 | $705,000 | $1,147,000 |
| Trunk Sewers | | | | | | | | |
| Lac La Belle-Oconomowoc East . . | 514,000 | 4,300 | 322,000 | 57,000 | 379,000 | 20,000 | 4,000 | 24,000 |
| Lac La Belle-Oconomowoc West . . | 590,000 | 1,100 | 370,000 | 14,000 | 384,000 | 23,000 | 1,000 | 24,000 |
| Silver Lake-Oconomowoc . . . . . . | 312,000 | 3,700 | 196,000 | 49,000 | 245,000 | 12,000 | 3,000 | 15,000 |
| North Lake-Oconomowoc . . . . . . | 4,412,000 | 33,000 | 2,768,000 | 440,000 | 3,208,000 | 176,000 | 28,000 | 204,000 |
| Subtotal | $ 5,828,000 | $ 42,100 | $ 3,656,000 | $ 560,000 | $ 4,216,000 | $ 231,000 | $ 36,000 | $ 267,000 |
| Total | $15,049,000 | $794,100 | $10,627,000 | $11,678,000 | $22,305,000 | $ 673,000 | $741,000 | $1,414,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Oconomowoc | | | | | | | | |
| Facilities. . . . . . . . . . . . . . . | $16,266,000 | $437,000 | $11,767,000 | $ 6,556,000 | $18,323,000 | $ 747,000 | $416,000 | $1,163,000 |
| Land . . . . . . . . . . . . . . . . . | 1,872,000 | - - | 1,073,000 | - - | 1,073,000 | 68,000 | - - | 68,000 |
| Subtotal | $18,138,000 | $437,000 | $12,840,000 | $ 6,556,000 | $19,396,000 | $ 815,000 | $ 416,000 | $1,231,000 |
| Trunk Sewers | | | | | | | | |
| Lac La Belle-Oconomowoc East . . | 514,000 | 4,300 | 322,000 | 57,000 | 379,000 | 20,000 | 4,000 | 24,000 |
| Lac La Belle-Oconomowoc West . . | 590,000 | 1,100 | 370,000 | 14,000 | 384,000 | 23,000 | 1,000 | 24,000 |
| Silver Lake-Oconomowoc . . . . . . | 312,000 | 3,700 | 196,000 | 49,000 | 245,000 | 12,000 | 3,000 | 15,000 |
| North Lake-Oconomowoc . . . . . . | 4,412,000 | 33,000 | 2,768,000 | 440,000 | 3,208,000 | 176,000 | 28,000 | 204,000 |
| Subtotal | $ 5,828,000 | $ 42,100 | $ 3,656,000 | $ 560,000 | $ 4,216,000 | $ 231,000 | $ 36,000 | $ 267,000 |
| Total | $23,966,000 | $479,100 | $16,496,000 | $ 7,116,000 | $23,612,000 | $1,046,000 | $452,000 | $1,498,000 |

[a] *This alternative does not include the cost of additional facilities related to the increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the added sludge-handling and -disposal requirements is $2,534,000. The estimated capital cost for construction of the added sludge-related facilities is $1,526,000, with an estimated average annual operation and maintenance cost of $95,000 over the design period 1975-2000.*

*Source: SEWRPC.*

### Alternative Plans—Hartland, Delafield-Nashotah, Nashotah-Nemahbin Lakes Subareas

The recommended plan for the Middle Rock River subregional area proposes that the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin sewer service areas be served by the Delafield-Hartland Water Pollution Control Commission treatment facility.

In 1975 only the Village of Hartland provided centralized sanitary sewer service to the Hartland subarea. The facility had an average hydraulic design capacity of about 0.35 mgd and provided a secondary level of waste treatment. It is anticipated that the proposed new facility at Delafield, which will serve existing and future growth for the three subareas, will require an average hydraulic design capacity of about 2.10 mgd in 1985 and about 3.37 mgd in the year 2000. This year 2000 design flow is is slightly lower than the 1990 design flow of 3.60 mgd anticipated under the regional sanitary sewerage system plan.

As previously noted, the Delafield-Hartland Water Pollution Control Commission has completed facilities planning for construction of new wastewater treatment and conveyance facilities designed to ultimately serve the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas. The plant is designed to provide secondary and tertiary waste treatment with advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. The facility is proposed to have an average hydraulic design capacity of 2.20 mgd. Construction of this facility is expected to begin in 1978.

In order to meet established water use objectives for the Bark River, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Bark River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that the Delafield-Hartland Water Pollution Control Commission plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analyses described earlier in this chapter, the effluent land application alternative and treatment and discharge alternative should be considered further for a plant the size of the Delafield-Hartland Water Pollution Control Commission facility. Accordingly, two alternative treatment alternatives were considered for this plan. The first alternative would provide for continued discharge of wastewater treatment plant effluent to the Bark River following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the provision of a land application system for disposal of secondary treatment plant effluent from the wastewater treatment facility. The recommended wastewater treatment plant performance standards for both of the alternatives are set forth in Table 201, and the two proposals are shown on Map 91.

The first alternative is based upon the provision of secondary waste treatment followed by advanced waste treatment for ammonia-nitrogen and phosphorus removal utilizing conventional chemical treatment for phosphorus removal, biological secondary treatment and nitrification, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to the Bark River. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas is about $16,624,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $13,674,000, with an estimated average annual operation and maintenance cost of $503,000 (see Table 202).

The second alternative treatment system is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural lands in the City of Delafield, the Village of Nashotah, and the Town of Summit were selected to receive the effluent from the Oconomowoc wastewater treatment facility. These sites would require that effluent be pumped about 10,000 feet.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alterna-

Table 201

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE HARTLAND, DELAFIELD-NASHOTAH, AND NASHOTAH-NEMAHBIN LAKES SEWER SERVICE AREAS: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| Delafield-Hartland Water Pollution Control Commission | 2.10 | 3.37 | Hartland, Delafield-Nashotah, Nashotah-Nemahbin Lakes | 12,100 | 18,200 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Effluent Aeration<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| Delafield-Hartland Water Pollution Control Commission | 2.10 | 3.37 | Hartland, Delafield-Nashotah, Nashotah-Nemahbin Lakes | 12,100 | 18,200 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application[b] | $BOD_5$ Discharge: 30.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

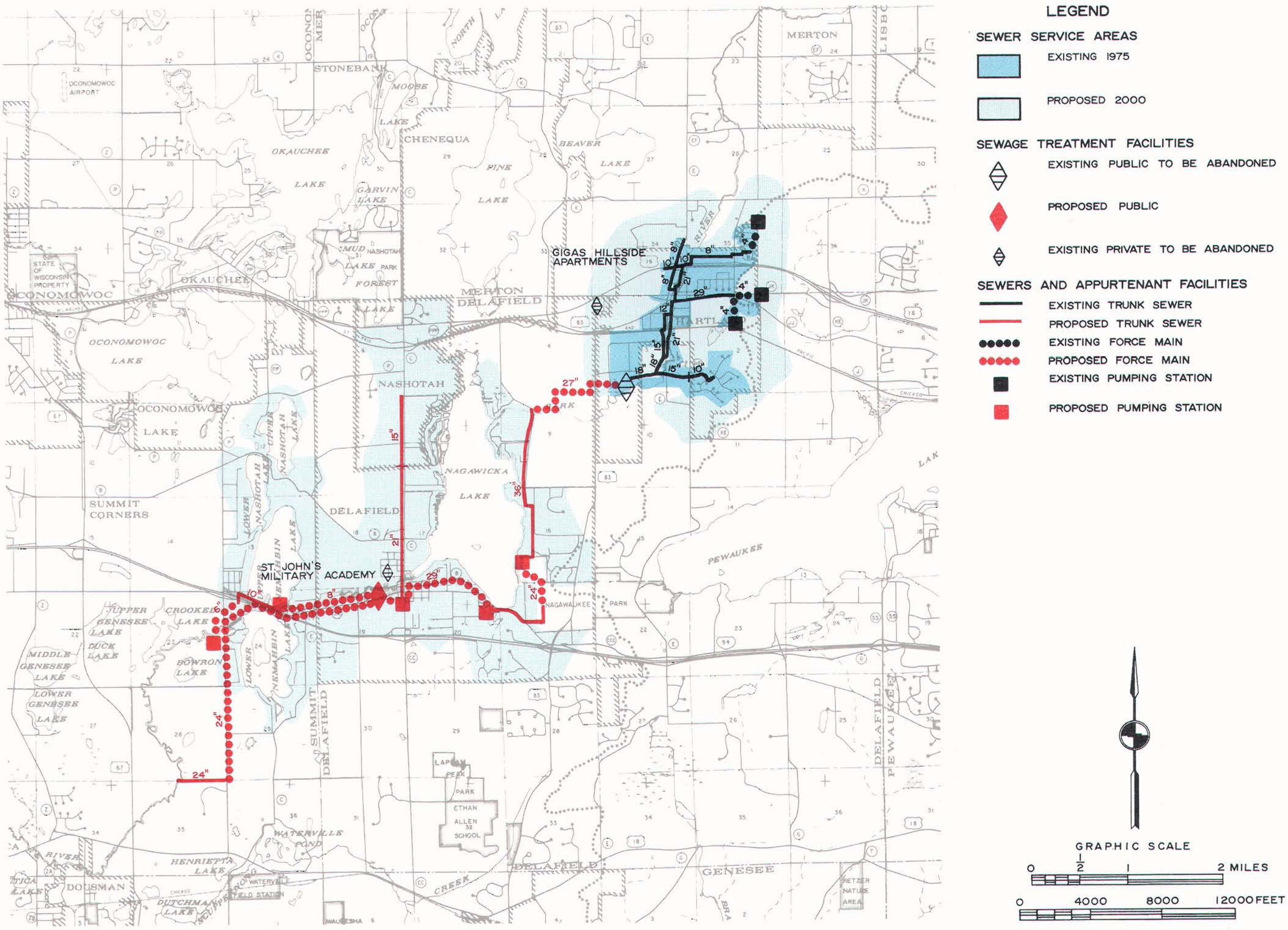
[a] *See Map 89.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Oconomowoc River.*

*Source: SEWRPC.*

Map 91

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE HARTLAND, DELAFIELD-NASHOTAH, AND NASHOTAH-NEMAHBIN LAKES SEWER SERVICE AREAS—MIDDLE ROCK RIVER SUBREGIONAL AREA: 2000




Both alternative sanitary sewerage system plans for the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes subareas of the Rock River watershed would concentrate treatment of sewage at one treatment facility. This combination of subareas closely reflects local planning efforts to establish one centralized treatment facility to serve the Bark River communities. In order to meet the established water use objectives for the Bark River, the proposed plant to be operated by the Delafield-Hartland Water Pollution Control Commission will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection and land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Bark River. Both treatment alternatives were considered. The treatment and discharge alternative is proposed under the areawide water quality management plan, even though it is estimated to be more costly, because it more closely reflects local planning efforts that are now being implemented.

*Source: SEWRPC.*

tive Plan 2 for the Hartland, Delafield-Nashotah, and Nashotah-Nemahbin Lakes sewer service areas is about $13,485,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $13,818,000, with an estimated average annual operation and maintenance cost of $270,000 (see Table 202).

On an equivalent annual cost basis, including the cost associated with the sludge-related facilities required with Alternative Plan 1, Alternative Plan 2 would be about 27 percent less costly to implement than would Alternative Plan 1. However, there are other less tangible, but nevertheless real, factors which should be considered. Alternative Plan 1 could be more readily implemented since planning for most of the major components of the alternative is complete, with construction expected to be started in 1978, and since this alternative represents a continuation of existing practices with the added construction and operational requirements associated with the recommended expansion and upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional

Table 202

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE HARTLAND, DELAFIELD-NASHOTAH, AND NASHOTAH-NEMAHBIN LAKES SEWER SERVICE AREAS: MIDDLE ROCK SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant Delafield-Hartland Water Pollution Control Commission Facilities | $ 6,711,000 | $453,000 | $5,073,000 | $6,863,000 | $11,936,000 | $321,000 | $435,000 | $ 756,000 |
| Outfall Sewer | 2,563,000 | 9,000 | 1,325,000 | 131,000 | 1,456,000 | 84,000 | 8,000 | 92,000 |
| Subtotal | $ 9,274,000 | $462,000 | $6,398,000 | $6,994,000 | $13,392,000 | $405,000 | $443,000 | $ 848,000 |
| Trunk Sewers | | | | | | | | |
| Hartland-Delafield | 3,907,000 | 32,000 | 2,451,000 | 429,000 | 2,880,000 | 155,000 | 27,000 | 182,000 |
| Nashotah-Delafield | 478,000 | 1,000 | 300,000 | 10,000 | 310,000 | 19,000 | 1,000 | 20,000 |
| Summit-Delafield | 594,000 | 8,000 | 373,000 | 105,000 | 478,000 | 24,000 | 7,000 | 31,000 |
| Subtotal | $ 4,979,000 | $ 41,000 | $3,124,000 | $ 544,000 | $ 3,668,000 | $198,000 | $ 35,000 | $ 233,000 |
| Total | $14,253,000 | $503,000 | $9,522,000 | $7,538,000 | $17,060,000 | $603,000 | $478,000 | $1,081,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant Delafield-Hartland Water Pollution Control Commission Facilities | $ 7,849,000 | $229,000 | $5,694,000 | $3,556,000 | $ 9,250,000 | $361,000 | $225,000 | $ 586,000 |
| Land | 990,000 | - - | 567,000 | - - | 567,000 | 36,000 | - - | 36,000 |
| Subtotal | $ 8,839,000 | $229,000 | $6,261,000 | $3,556,000 | $ 9,817,000 | $397,000 | $225,000 | $ 622,000 |
| Trunk Sewers | | | | | | | | |
| Hartland-Delafield | 3,907,000 | 32,000 | 2,451,000 | 429,000 | 2,880,000 | 155,000 | 27,000 | 182,000 |
| Nashotah-Delafield | 478,000 | 1,000 | 300,000 | 10,000 | 310,000 | 19,000 | 1,000 | 20,000 |
| Summit-Delafield | 594,000 | 8,000 | 373,000 | 105,000 | 478,000 | 24,000 | 7,000 | 31,000 |
| Subtotal | $ 4,979,000 | $ 41,000 | $3,124,000 | $ 544,000 | $ 3,668,000 | $198,000 | $ 35,000 | $ 233,000 |
| Total | $13,818,000 | $270,000 | $9,385,000 | $4,100,000 | $13,485,000 | $595,000 | $260,000 | $ 855,000 |

[a] *This alternative does not include the cost of additional facilities related to the increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the added sludge-handling and -disposal requirements is $1,532,000. The estimated capital cost for construction of the added sludge-related facilities is $999,000, with an estimated average annual operation and maintenance cost of $53,000 over the design period 1975-2000.*

*Source: SEWRPC.*

arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 1,100 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management. Alternative Plan 2 also requires the construction of a major conveyance system to transport treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1.

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, based on the existing stage of implementation, environmental impacts, and ease of implementation, Alternative Plan 1—the treatment and discharge alternative—is recommended.

Proposed Plan—Dousman Subarea

In 1975 the wastewater treatment facility serving the Dousman sewer service area had an average hydraulic design capacity of 0.12 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Dousman sewer service area of about 0.22 mgd in

1985 and about 0.34 mgd in the year 2000. This year 2000 design flow is somewhat lower than the estimated 1990 design flow of 0.46 mgd anticipated under the regional sanitary sewerage system plan.

During 1978 the Village of Dousman completed facilities planning for upgrading and expansion of a new wastewater treatment plant. The proposed wastewater treatment plant is designed to provide secondary and tertiary waste treatment, advanced waste treatment for nitrification, and auxiliary waste treatment for effluent disinfection. The plant is proposed to have an average hydraulic design capacity of about 0.35 mgd.

In order to meet the established water use objectives for the Bark River, this facility will need to provide either a secondary level of waste treatment with auxiliary treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Bark River. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan with regard to the provision of advanced waste treatment for nitrification and phosphorus removal. That plan recommended that the Dousman plant provide secondary waste treatment followed by auxiliary waste treatment for effluent aeration and disinfection prior to discharge of effluent to the Bark River.

As previously noted, local facilities planning work has been completed for a modification to the Village of Dousman wastewater treatment plant, with the detailed design work expected to be started in 1978. Facilities are proposed which will provide for all of the treatment steps needed under the treatment and discharge alternative except the phosphorus removal component.

Because of this existing stage of implementation, the decision to provide treatment followed by discharge to surface waters has been treated as a committed local decision even though the areawide analysis indicates that, on a generalized basis, an effluent land application alternative may be less costly than providing the levels of treatment needed prior to discharge to surface waters. The proposed facilities should be designed to allow for expansion to ultimately accommodate the facilities needed to reduce the total phosphorus concentration to approximately 1.0 mg/l. Future local facilities planning efforts designed to evaluate the phosphorus reduction component of the recommendations should further consider the land application alternative. The recommended performance standards for the Village of Dousman wastewater treatment plant are set forth in Table 203, and the proposal is shown on Map 92.

The total present worth over a 50-year analysis period of construction and operation of proposed treatment facilities for the Dousman sewer service area is about \$3,071,000. The estimated capital cost for constructing the necessary additional treatment facilities is \$1,746,000, with an estimated average annual operation and maintenance cost of \$116,000 (see Table 204).

Proposed Plan—Wales Subarea

As already noted, in 1975 the Village of Wales was not served by centralized sanitary sewers. It is proposed that centralized sanitary sewer service be provided to the Village of Wales and its environs. It is estimated that the total average hydraulic loading from this area will be about 0.53 mgd in 1985 and about 0.65 mgd in the year

Table 203

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE DOUSMAN SEWER SERVICE AREA: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Dousman | 0.22 | 0.34 | Dousman | 1,500 | 2,100 | Secondary<br>Advanced<br><br><br>Auxiliary | Activated Sludge<br>Nitrification[b]<br><br>Phosphorus Removal[b]<br>Effluent Aeration<br><br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

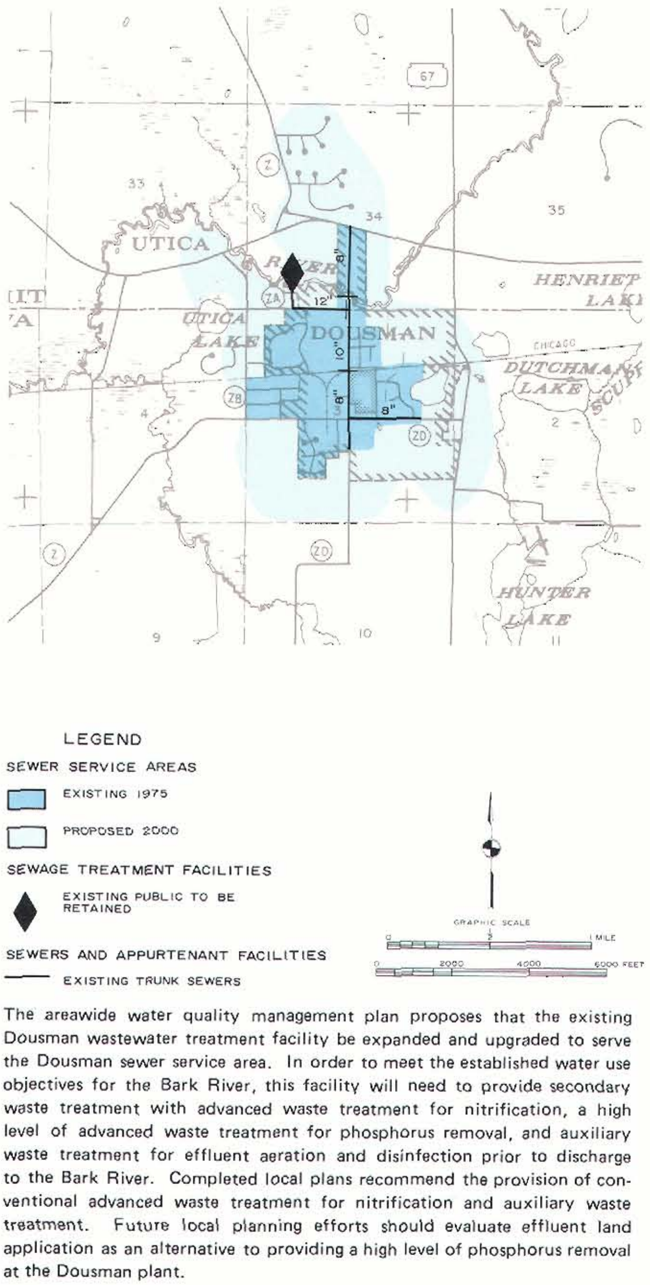
[a] *See Map 89.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Bark River.*

*Source: SEWRPC.*

Map 92

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE DOUSMAN SEWER SERVICE AREA— MIDDLE ROCK RIVER SUBREGIONAL AREA: 2000**




The areawide water quality management plan proposes that the existing Dousman wastewater treatment facility be expanded and upgraded to serve the Dousman sewer service area. In order to meet the established water use objectives for the Bark River, this facility will need to provide secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Bark River. Completed local plans recommend the provision of conventional advanced waste treatment for nitrification and auxiliary waste treatment. Future local planning efforts should evaluate effluent land application as an alternative to providing a high level of phosphorus removal at the Dousman plant.

*Source: SEWRPC.*

2000. The year 2000 design flow is considerably larger than the 1990 design flow of 0.23 mgd anticipated under the regional sanitary sewerage system plan. The proposed plan for the Wales area includes the construction of a new wastewater treatment plant to serve this subarea.

In order to meet established water use objectives for the Scuppernong Creek and the Rock River, the Wales wastewater treatment plant will need to provide either a secondary level of waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Scuppernong Creek. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the provision of advanced waste treatment for phosphorus removal. That plan recommended the provision of secondary waste treatment followed by advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application would be less costly than providing secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to surface waters for facilities the size of the proposed Wales treatment plant. Thus, the areawide water quality management plan for the Wales area is based upon the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine the alternatives providing for discharge to surface waters as well as the land application alternative. Should local facility planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with the effluent discharged to surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration to about 0.1 mg/l. The recommended performance standards for the Wales wastewater treatment plant are set forth in Table 205, and the proposal is shown on Map 93.

The total present worth over a 50-year analysis period of construction and operation of proposed treatment facilities is about $3,451,000. The estimated capital cost for construction of the necessary treatment facilities at Wales is $2,924,000, with an estimated average annual operation and maintenance cost of $86,000 (see Table 206).

Proposed Plan—Ethan Allen School Subarea

In 1975 the private wastewater treatment facility serving the Ethan Allen School sewer service area had an average hydraulic capacity 0.17 mgd and provided a secondary level of waste treatment followed by use of a soil absorption system for the treated effluent. This facility

Table 204

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE DOUSMAN SEWER SERVICE AREA: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Village of Dousman. . . . . . | $1,746,000 | $116,000 | $1,320,000 | $1,751,000 | $3,071,000 | $75,000 | $111,000 | $195,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $1,746,000 | $116,000 | $1,320,000 | $1,751,000 | $3,071,000 | $75,000 | $111,000 | $195,000 |

*Source: SEWRPC.*

Table 205

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WALES SEWER SERVICE AREA: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Wales | 0.53 | 0.65 | Wales | 2,500 | 3,100 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application[b] | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] *See Map 89.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Scuppernong Creek.*

*Source: SEWRPC.*

Table 206

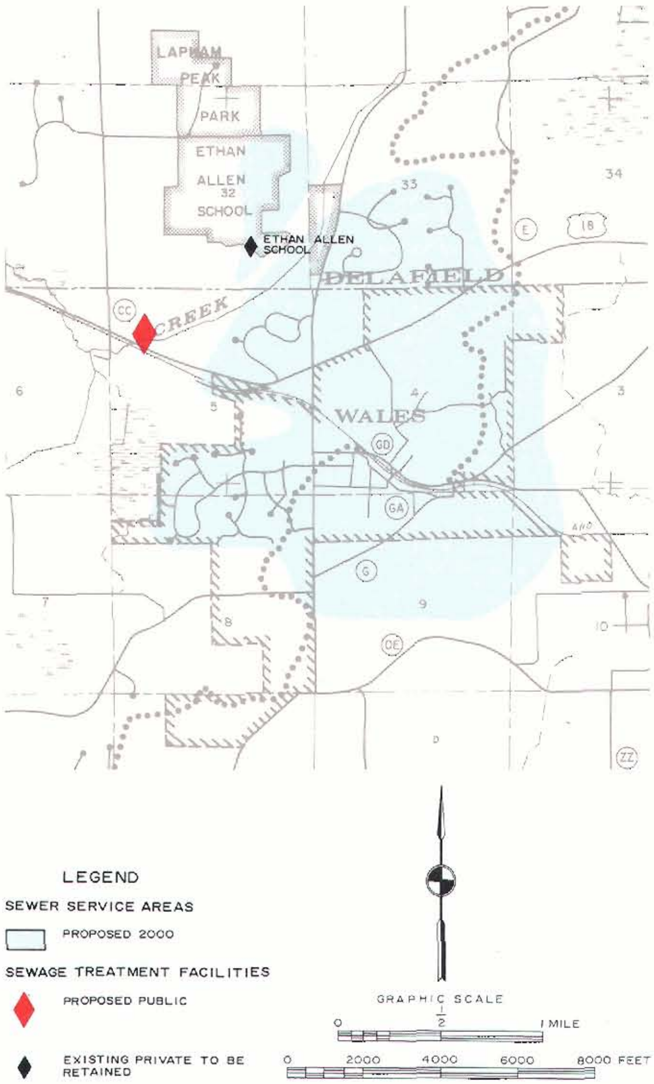
DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WALES SEWER SERVICE AREA: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Wales | | | | | | | | |
| Facilities. . . . . . . . . . . | $2,699,000 | $86,000 | $2,082,000 | $1,240,000 | $3,322,000 | $132,000 | $79,000 | $211,000 |
| Land . . . . . . . . . . . . . | 225,000 | - - | 129,000 | - - | 129,000 | 8,000 | - - | 8,000 |
| Subtotal | $2,924,000 | $86,000 | $2,211,000 | $1,240,000 | $3,451,000 | $140,000 | $79,000 | $219,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $2,924,000 | $86,000 | $2,211,000 | $1,240,000 | $3,451,000 | $140,000 | $79,000 | $219,000 |

*Source: SEWRPC.*

Map 93

**PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE WALES AND ETHAN ALLEN SCHOOL SERVICE AREAS— MIDDLE ROCK RIVER SUBREGIONAL AREA: 2000**




Currently, the Village of Wales relies on onsite septic tank systems for treatment of wastewater. Because of historic growth and development trends, as well as planned land uses, it is proposed under the areawide water quality management plan that the Village of Wales establish a centralized sanitary sewerage system. The plan further proposes the existing Ethan Allen School wastewater treatment facility be retained to serve the Ethan Allen sewer service area. In order to meet the established water use objectives for the Scuppernong Creek, the proposed Wales facility will need to provide either secondary waste treatment and land application of plant effluent, or secondary waste treatment with advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Scuppernong Creek. It is proposed that the current method of effluent disposal—through a soil absorption treatment system—be maintained for the Ethan Allen School treatment facility. The continued successful operation of the soil absorption system at the Ethan Allen School should be carefully monitored. If the system should fail, or should it become necessary to expand or upgrade the existing system in the future, the abandonment of this facility and connection to the Wales sanitary sewerage system should be examined.

*Source: SEWRPC.*

has been classified as a private wastewater treatment plant in the inventory of facilities. It is anticipated that future growth will require an average hydraulic design capacity for the Ethan Allen School of about 0.13 mgd in 1985 and about 0.17 mgd in the year 2000.

In order to meet established water use objectives for the Scuppernong Creek and the Rock River, this facility will need to provide either a secondary level of wastewater treatment followed by land application of effluent, or secondary waste treatment followed by conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Scuppernong Creek.

Specific recommendations for the level of treatment at the Ethan Allen School were not included in the regional sanitary sewerage system plan, which recommended that the plant continue to provide a level of waste treatment adequate to meet the water quality objectives and standards for the stream. The present wastewater treatment facility was recently reconstructed and is large enough to meet the projected year 2000 demand. With the effluent discharge to a seepage lagoon, the continued operation of the existing plant is compatible with water use objectives. Thus, no change in the existing system of wastewater management is recommended for the Ethan Allen School subarea. The continued successful operation of the soil absorption system at the Ethan Allen School should be carefully monitored. If the system should fail, or should it become necessary to expand or upgrade the existing system in the future, the abandonment of this existing facility and connection to the Wales sanitary sewerage system should be examined. The recommended performance standards for the Ethan Allen School wastewater treatment plant are set forth in Table 207, and the proposal is shown on Map 93.

The total present worth over a 50-year analysis period of construction and operation of the existing treatment facilities is about $496,000. The estimated capital cost of major replacement items at the Ethan Allen School is $240,000, with an estimated average annual operation and maintenance cost of $20,000 (see Table 208).

Private Wastewater Treatment Plants

There are three known private wastewater treatment facilities in the Middle Rock River subregional area which serve isolated enclaves of urban land uses and generally treat wastes which can be accepted in public sanitary sewerage systems. These facilities currently discharge treated wastewater to the streams and groundwater in the Middle Rock River subregional area. These three facilities serve the Gigas Hillside Apartments in the Town of Delafield, St. John's Military Academy in the City of Delafield, and Ethan Allen School in the Town of Delafield. Two of these plants lie within the year 2000 proposed service areas.

Table 207

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE ETHAN ALLEN SCHOOL SEWER SERVICE AREA: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Ethan Allen School | 0.13 | 0.17 | Ethan Allen School | 600 | 800 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Soil Absorption | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100<br>- - |

[a]See Map 89.

Source: SEWRPC.

Table 208

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE ETHAN ALLEN SCHOOL SEWER SERVICE AREA: MIDDLE ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant Ethan Allen School. . . . . . | $240,000 | $20,000 | $181,000 | $315,000 | $496,000 | $11,000 | $20,000 | $31,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $240,000 | $20,000 | $181,000 | $315,000 | $496,000 | $11,000 | $20,000 | $31,000 |

Source: SEWRPC.

These facilities would be abandoned upon implementation of the proposed sewer system plan for the Hartland and Delafield-Nashotah sewer service areas. The remaining facility—that serving the Ethan Allen School— is proposed to be retained. The recommended treatment level and estimated cost for this facility is discussed in the previous section.

Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are nine enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area as shown on Map 89. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are listed in Table 209. In a general analysis described earlier in this chapter, the cost of providing public sewerage service to these enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that analysis, it was concluded that wastewater treatment for these nine enclaves of unsewered urban development should be provided in one of two ways.

For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. Seven of the nine unsewered urban areas are included in this category—the Village of Merton, the Town of Delafield—Section 28, the Town of Lisbon—Section 4 and Section 15, Ashippun Lake, Golden Lake, and Hunters Lake, all in Waukesha County.

For the remaining urban enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. These enclaves, which should consider alternative methods of onsite waste disposal as well as an intensive inspection and maintenance program for conventional systems, are Lake Keesus and Pretty Lake in Waukesha County.

Sanitary Sewer System Flow Relief Devices

In 1975 there were six known sanitary sewer system flow relief devices located in the Middle Rock River

Table 209

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE MIDDLE ROCK RIVER SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population | | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | | 1975 | 2000 | |
| | Waukesha County | | | |
| 1 | Village of Merton | 586 | 528 | 1.5 |
| 2 | Town of Delafield–Section 28 | 144 | 169 | - - |
| 3 | Town of Lisbon–Section 4 | 201 | 396 | 2.5 |
| 4 | Town of Lisbon–Section 15 | 128 | 123 | 1.0 |
| 5 | Ashippun Lake | 246 | 195 | 1.5 |
| 6 | Golden Lake | 165 | 186 | 2.3 |
| 7 | Hunters Lake | 90 | 55 | - - |
| 8 | Lake Keesus | 594 | 656 | 1.1 |
| 9 | Pretty Lake | 197 | 154 | 4.4 |
| Total | | 2,351 | 2,462 | - - |

[a] *See Map 89.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

subregional area. The proposed plan recommends that local planning efforts include the formulation of plans for the elimination of these sewage flow relief devices.

Other Known Point Sources of Wastewater

There are a total of seven known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Middle Rock River subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of $BOD_5$, ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for the public and private wastewater treatment plants in the Region discharging to the same or similar water bodies. Thus, in most cases no further treatment recommendations were advanced for these other point sources with regard to these constituents. However, it is recommended that these point sources in general reduce discharge temperatures to $89^oF$ or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 210.

There are no costs calculated for these point sources in the Middle Rock River subregional area. From the limited data available on these point sources, only one point source appears to require treatment consideration. That discharge is the Carnation Can Company in the City of Oconomowoc, which is proposed to be connected to the Oconomowoc sanitary sewerage system. The cost of the treatment associated with this connection is included in the cost of the Oconomowoc public wastewater treatment facility discussed earlier in this section.

## LOWER ROCK RIVER SUBREGIONAL AREA

The Lower Rock River subregional area consists of all that part of the Rock River watershed in Walworth County together with urban concentrations in the Fox River watershed at the western end of Lake Geneva. Several subwatersheds comprise the Lower Rock River subregional area, including the Whitewater Creek subwatershed, the Turtle Creek subwatershed, the Jackson Creek subwatershed, the Piscasaw Creek subwatershed, and the Sharon Creek subwatershed. Major concentrations of urban development are found in the Cities of Delavan, Elkhorn, and Whitewater; the Villages of Darien, Fontana, Sharon, Walworth, and Williams Bay; and the Delavan Lake area in the Town of Delavan.

Centralized sanitary sewer service in the Lower Rock River subregional area was provided by eight systems in 1975: those operated by the Cities of Delavan, Elkhorn, and Whitewater; and the Villages of Darien, Fontana, Sharon, Walworth, and Williams Bay. Together, the service areas of these eight systems comprised about 10.9 square miles and served an estimated population of about 28,800 persons. In 1975 there were about 13,400 persons residing in the subregional area not served by centralized sanitary sewerage facilities. Specific population, service area, and related characteristics of the eight existing systems are presented in Volume One, Chapter V of this report, and in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975.

Table 210

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION– MIDDLE ROCK RIVER SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Carnation Can Company . . . | City of Oconomowoc | 0.018 | Oconomowoc River via Storm Sewer | $BOD_5$, Oil and Grease |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

Sewer Service Analysis Areas

A total of 10 sewer service analysis areas may be identified within the Lower Rock River subregional area (see Table 211). These 10 sewer service analysis areas are shown on Map 94, and may be described as follows:

1. Area A—This area consists of the City of Whitewater and environs, including existing and anticipated future urban development in that portion of the City of Whitewater lying in Jefferson County outside of the Southeastern Wisconsin Region. In 1975 sanitary sewer service was provided in this area to about 2.4 square miles, having a total resident population, including resident students attending the University of Wisconsin-Whitewater, of about 11,100 persons. This population includes 1,800 persons, most of whom are UW-Whitewater students, residing in Jefferson County. The total area anticipated to be served by the year 2000 approximates 4.34 square miles, with a projected resident population of about 19,500 persons. This population includes 2,500 persons, most of whom are UW-Whitewater students, residing in Jefferson County. This represents a substantial increase in planned population from the 15,500 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Whitewater" sewer service area in the ensuing discussion.

2. Area B—This area consists of the City of Elkhorn and environs. In 1975 sanitary sewer service was provided in this area to about 2.4 square miles, having a total resident population of about 4,400 persons. The total area anticipated to be served by the year 2000 approximates 4.93 square miles, with a projected resident population of about 8,100 persons. This represents a slight increase in planned population from the 8,000 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Elkhorn" sewer service area in the ensuing discussion.

3. Area C—This area consists of the City of Delavan and environs. In 1975 sanitary sewer service was provided in this area to about 2.0 square miles, having a total resident population of about 5,800

Table 211

SELECTED CHARACTERISTICS OF SEWER SERVICE AREAS IN THE LOWER ROCK RIVER SUBREGIONAL AREA: 1975, 1985, AND 2000

| Sewer Service Analysis Area[a] | | Existing 1975 | | | | Planned 1985 | | Planned 2000 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Letter | Name | Area Served (square miles) | Population Served | Average Hydraulic Loading (mgd) | Unserved Population Residing in the Proposed 2000 Service Area | Population Served | Design Hydraulic Loading (mgd) | Area Served (square miles) | Population Served | Design Hydraulic Loading (mgd) |
| A | Whitewater | 2.38[b] | 11,000 | 1.14 | 100 | 14,300[c] | 2.27 | 4.34 | 19,500[d] | 3.37 |
| B | Elkhorn | 2.42 | 4,400 | 0.69 | 300 | 5,800 | 0.98 | 4.93 | 8,100 | 1.47 |
| C | Delavan | 2.01 | 5,800 | 0.59 | 400 | 7,400 | 0.93 | 3.17 | 8,800 | 1.22 |
| D | Delavan Lake | - - | - - | - - | 2,800[e] | 5,600[f] | 1.18 | 3.12 | 5,600[f] | 1.18 |
| E | Darien | 0.47 | 1,000 | 0.14 | - - | 1,400 | 0.22 | 1.13 | 2,000 | 0.35 |
| F | Williams Bay | 1.21 | 1,700 | 0.20 | 700[e] | 5,600[g] | 1.02 | 3.38 | 6,900[g] | 1.29 |
| G | Fontana | 1.42 | 1,800 | 0.66 | 300[e] | 3,800[h] | 1.08 | 2.81 | 5,200[h] | 1.37 |
| H | Walworth | 0.47 | 1,700 | 0.17 | 100 | 2,300 | 0.30 | 1.62 | 3,100 | 0.46 |
| I | Sharon | 0.53 | 1,400 | 0.08 | - - | 1,900 | 0.19 | 1.24 | 2,600 | 0.33 |
| J | Walworth County Institutions | - - | - - | - - | 700 | 800 | 0.17 | 0.27 | 1,000 | 0.21 |
| | Total | 10.91 | 28,800 | 3.67 | 5,400 | 48,900 | 8.34 | 26.01 | 62,800 | 11.25 |

[a] *See Map 94.*

[b] *Includes 141 acres (0.22 square mile) in Jefferson County.*

[c] *Includes an estimated 2,000 people in Jefferson County.*

[d] *Includes an estimated 2,500 people in Jefferson County.*

[e] *Does not include seasonal resident population on Delavan Lake and Lake Geneva.*

[f] *Includes an estimated seasonal resident population of 2,900 persons.*

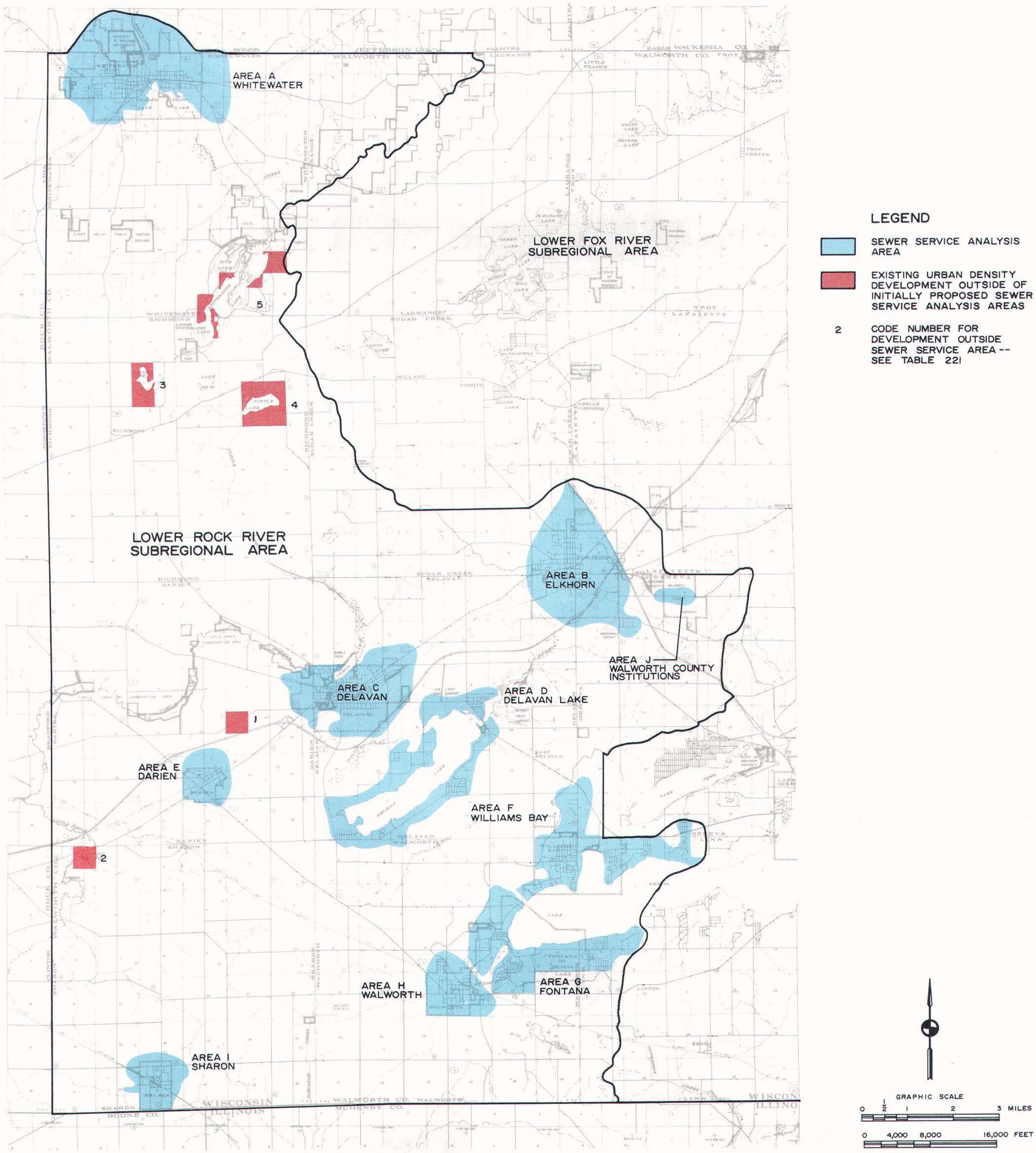
[g] *Includes an estimated seasonal resident population of 2,500 persons.*

[h] *Includes an estimated seasonal resident population of 1,000 persons.*

*Source: SEWRPC.*

## Map 94

### SEWER SERVICE ANALYSIS AREAS: LOWER ROCK RIVER SUBREGIONAL AREA




Ten individual sewer service areas were identified within the Lower Rock River subregional area. Except for a major concentration of urban development along the shoreline of Delavan Lake in the Town of Delavan Lake and the Walworth County Institutions, these 10 sewer service areas consist of incorporated cities and villages. In 1975 there were about 42,200 persons residing in this portion of the Rock River watershed, of which about 28,800 were served with centralized sanitary sewers and 13,400 by private septic tank sewage disposal systems. By the year 2000, about 62,800 persons are expected to reside in these 10 sewer service areas, which will approximate 26 square miles.

*Source: SEWRPC.*

persons. The total area anticipated to be served by the year 2000 approximates 3.17 square miles, with a projected resident population of about 8,800 persons. This represents a very slight decrease in planned population from the 8,900 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Delavan" sewer service area in the ensuing discussion.

4. Area D—This area consists of urban development along the shoreline of Delavan Lake in the Town of Delavan. About 2,800 persons resided in this area on a year-round basis in 1975, but no centralized sanitary sewer service was provided. The Delavan Lake Sanitary District has been formed to provide centralized sanitary sewer service to this concentration of urban development. The total area anticipated to be served with centralized sanitary sewer service by the year 2000 approximates 3.12 square miles, with a projected resident population of about 5,600 persons, including an estimated seasonal resident population of about 2,900 persons. This represents a small decrease in the planned population from the 5,800 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Delavan Lake" sewer service area in the ensuing discussion.

5. Area E—This area consists of the Village of Darien and environs. In 1975 sanitary sewer service was provided in this area to about 0.5 square mile, having a total resident population of about 1,000 persons. The total area anticipated to be served by the year 2000 approximates 1.13 square mile, with a projected resident population of about 2,000 persons. This represents a decrease in the planned population from the 2,800 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Darien" sewer service area in the ensuing discussion.

6. Area F—This area consists of the Village of Williams Bay and environs, including urban development along the shorelines of Lake Geneva in the Towns of Geneva and Linn. In 1975 sanitary sewer service was provided in this area to about 1.2 square miles, having a total resident population of about 1,700 persons. The total area anticipated to be served by the year 2000 approximates 3.38 square miles, with a projected resident population of about 6,900 persons, including an estimated seasonal resident population of about 2,500 persons. This represents an increase in the planned population from the 6,500 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Williams Bay" sewer service area in the ensuing discussion.

7. Area G—This area consists of the Village of Fontana and environs, including urban development along the shoreline of Lake Geneva in the Town of Linn. In 1975 sanitary sewer service was provided in this area to about 1.4 square miles, having a total resident population of about 1,800 persons. The total area anticipated to be served by the year 2000 approximates 2.81 square miles, with a projected resident population of about 5,200 persons, including an estimated seasonal resident population of about 1,000 persons. This represents an increase in the planned population from the 3,100 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Fontana" sewer service area in the ensuing discussion.

8. Area H—This area consists of the Village of Walworth and environs. In 1975 sanitary sewer service was provided in this area to about 0.5 square mile, having a total resident population of about 1,700 persons. The total area anticipated to be served by the year 2000 approximates 1.62 square miles, with a projected resident population of about 3,100 persons. This represents a decrease in the planned population from the 5,200 persons forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Walworth" sewer service area in the ensuing discussion.

9. Area I—This area consists of the Village of Sharon and environs. In 1975 sanitary sewer service was provided in this area to about 0.5 square mile, having a total resident population of about 1,400 persons. The total area anticipated to be served by the year 2000 approximates 1.24 square miles, with a projected resident population of about 2,600 persons. This is the same planned population forecast for the area for 1990 in the regional sanitary sewerage system plan. This subarea is referenced as the "Sharon" sewer service area in the ensuing discussion.

10. Area J—This area consists of the Lakeland nursing home and associated Walworth County Institutions in the Town of Geneva. While the sanitary sewerage system operated by Walworth County to serve the nursing home and county institutions is not, strictly speaking, a public centralized sanitary sewerage system, the service area has some characteristics of a small urban area, and has been considered to be a public sewer service area for regional sewerage system planning. The total nursing home and institutions population anticipated to be served by the year 2000 is about 1,000 persons. This subarea is referenced as the "Walworth County Institutions" sewer service area in the ensuing discussion.

Formulation of Alternatives

As noted earlier in this chapter, a systematic procedure was utilized in the regional sanitary sewerage system plan for the formulation and evaluation of alternative public sanitary sewerage system plans. First, the potential for interconnection of community sanitary sewerage systems was evaluated. Four interconnections in the Lower Rock River subregional area—Elkhorn to Delavan-Delavan Lake, Darien to Delavan-Delavan Lake, Williams Bay to Walworth, and Fontana to Walworth—were found to be potentially feasible through the application of the Wisconsin Department of Natural Resources guidelines on distances between and populations of communities. Preliminary economic analyses were then made for those interconnections which were found to be potentially feasible, with more detailed analyses conducted for those systems which continued to appear feasible following the preliminary analyses. Detailed economic analyses were made for the following alternatives:

1. Two alternative plans for the Delavan-Delavan Lake and Elkhorn sewer service areas, including an alternative providing individual sewage treatment facilities at each of the two sewer service areas and an alternative providing for a single sewage treatment facility at the Delavan-Delavan Lake sewage treatment plant site.

2. Two alternative plans for the Delavan-Delavan Lake and Darien sewer service areas, including an alternative providing individual sewage treatment facilities at each of the two sewer service areas and an alternative providing for a single sewage treatment facility at the Delavan-Delavan Lake sewage treatment plant site.

3. Three alternative plans for the Fontana, Walworth, and Williams Bay sewer service areas, including an alternative providing individual sewage treatment facilities at each of the three sewer service areas; an alternative providing for two sewage treatment facilities, one at Williams Bay and the other at Walworth to serve Fontana and Walworth; and an alternative providing for a single sewage treatment facility at the Walworth sewage treatment site to serve all three sewer service areas.

A detailed discussion of these alternative proposals can be found in Chapter 11 of SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin. That plan recommended that wastewater treatment for the Delavan-Delavan Lake and Elkhorn sewer service areas be consolidated at a single treatment facility to be located at Delavan, with separate wastewater treatment facilities serving each of the other sewer service areas in the subregional area. These plan recommendations were based on a presumption that the current soil absorption effluent disposal systems at the Villages of Darien, Fontana, and Williams Bay would continue to be viable. Should such soil absorption systems fail, the plan recommended that consideration be given to joint treatment of sewage from the Villages of Fontana and Williams Bay at the proposed new Walworth treatment plant site, and that treatment alternatives for the Darien sewer service area be reevaluated.

Because of the demonstrated failure of the existing soil absorption effluent disposal systems in Darien and Fontana, treatment alternatives for these areas should be reevaluated. The connection of the Darien sewer service area to the Delavan sewer service, which was considered to be potentially feasible in the regional sanitary sewerage system plan, was reconsidered under the areawide water quality management planning program as an alternative to separate wastewater treatment for Darien. With regard to the alternative plan recommendations for the Fontana, Walworth, and Williams Bay sewer service areas, a local facility plan has been developed that considers various alternative plans for these areas. Interconnection of the Lake Geneva and Lake Como sewer service areas was also considered in the local facility plan. With regard to the number and location of public wastewater treatment facilities serving the Fontana, Walworth, and Williams Bay areas, the findings of the local facility plan—which concluded that the three areas should be interconnected for sewage treatment plant purposes—are incorporated into the proposed plan description included in this section.

Subsequent local facilities planning has been completed for the Elkhorn, Delavan, and Delavan Lake sewer service areas, with the recommendations of that local facility plan regarding the number and location of treatment facilities being the same as those of the regional sanitary sewerage system plan. Local facility planning efforts have also been completed for the City of Whitewater, and are being conducted for the Darien and Sharon sewer service areas.

Since local facility planning has addressed the number and location of all the sewer service areas in the Lower Rock River subregional area except for the Darien and Sharon areas, no further alternative analyses are proposed with regard to the number and location of treatment facilities except for the Darien-Delavan sewer service area interconnection noted above. No potential interconnection alternatives appear to be feasible for the Sharon sewer service area.

Accordingly, it was determined that the following sanitary sewerage system plans for the 10 sewer service areas that lie with the Lower Rock River subregional area should be prepared and evaluated:

1. A proposed plan for the Whitewater sewer service area.

2. Two alternative plans for the Darien, Delavan, Delavan Lake, Elkhorn, and Walworth County Institutions sewer service areas.

3. Two alternative plans—only with regard to type of treatment—for the Fontana, Walworth, and Williams Bay sewer service areas.

4. A proposed plan for the Sharon sewer service area.

The recommended plan for sanitary sewerage in the Lower Rock River subregional area as developed under the regional sanitary sewerage system plan is incorporated, with certain modifications indicated as desirable by subsequent system and facilities planning efforts, as an integral part of the areawide water quality management plan. Results of water quality simulations are presented under the previous section on the diffuse source control element recommendations for the Rock River watershed.

Sanitary sewerage system plans for each of the 10 sewer service areas that lie in the Lower Rock River subregional area are described in the following sections.

Alternative Plans—Whitewater Subarea

In 1975, the wastewater treatment facility serving the Whitewater sewer service area had an average hydraulic design capacity of 2.50 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Whitewater sewer service areas of about 2.27 mgd in 1985 and about 3.37 mgd in the year 2000. This year 2000 design flow is lower than the estimated 1990 design flow of 3.66 mgd anticipated under the regional sanitary sewerage system plan.

In 1976 the Whitewater sewer service area had completed facilities planning for construction of a new wastewater treatment plant. The proposed wastewater treatment plant is to be located one half mile north of the existing facility, and is designed to provide secondary waste treatment, advanced waste treatment for phosphorus removal, tertiary treatment, and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Whitewater Creek via a 3,000-foot outfall sewer. The plant is proposed to have an average hydraulic design capacity of about 3.60 mgd.

In order to meet established water use objectives for Whitewater Creek, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that the plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analysis described earlier in this chapter, the effluent land application alternative and treatment and discharge alternative should be considered further for a plant the size of the Whitewater facility. Accordingly, two treatment alternatives were considered for the Whitewater sewer service area. The first alternative would provide for continued discharge of the Whitewater wastewater treatment plant effluent to Whitewater Creek following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the provision of a land application system for disposal of secondary treatment plant effluent from the Whitewater wastewater treatment facility. The recommended wastewater treatment plant performance standards for both of the alternatives are set forth in Table 212, and the two proposals are shown on Map 95.

The first alternative is based upon the provision of secondary waste treatment with advanced waste treatment for ammonia-nitrogen and phosphorus removal utilizing conventional chemical treatment for phosphorus removal, biological nitrification, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to Whitewater Creek. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Whitewater sewer service area is about $10,312,000. The estimated capital cost for constructing the necessary additional and conveyance treatment facilities is $5,859,000, with an estimated average annual operation and maintenance cost of $398,400 (see Table 213).

The second alternative is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent. For areawide systems level analysis purposes, rural land adjoining the treatment plant to the north was selected to receive the effluent from the Whitewater wastewater treatment facility. This site would require that effluent be pumped a minimal distance. The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 2 for the Whitewater sewer service area is about $9,866,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $9,016,000, with an estimated average annual operation and maintenance cost of $229,400 (see Table 213).

On an equivalent annual cost basis, including the cost of the sludge-related facilities required with the first alternative, Alternative Plan 1 would be about 17 percent more costly to implement than would Alternative Plan 2. However, there are other less tangible, but nevertheless real, factors which should be considered. Alternative Plan 1 can be more readily implemented, since planning for most of the major components of the alternative is complete and since this alternative represents a continuation of existing practices with the added construction and operational requirements associated with the recommended expansion and upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional

Table 212

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WHITEWATER SEWER SERVICE AREA: LOWER ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent *average monthly limits*) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Whitewater | 2.27 | 3.37 | Whitewater | 12,300 | 16,900 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Aeration<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Alternative Plan 2 | | | | | | | | |
| City of Whitewater | 2.27 | 3.37 | Whitewater | 12,300 | 16,900 | Secondary<br>Auxiliary<br><br>Advanced | Activated Sludge<br>Disinfection<br><br>Land Application[b] | $BOD_5$ Discharge: 30.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |

[a] *See Map 94.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to the Fox River.*

*Source: SEWRPC.*

Table 213

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WHITEWATER SEWER SERVICE AREA: LOWER ROCK RIVER SUBREGIONAL AREA

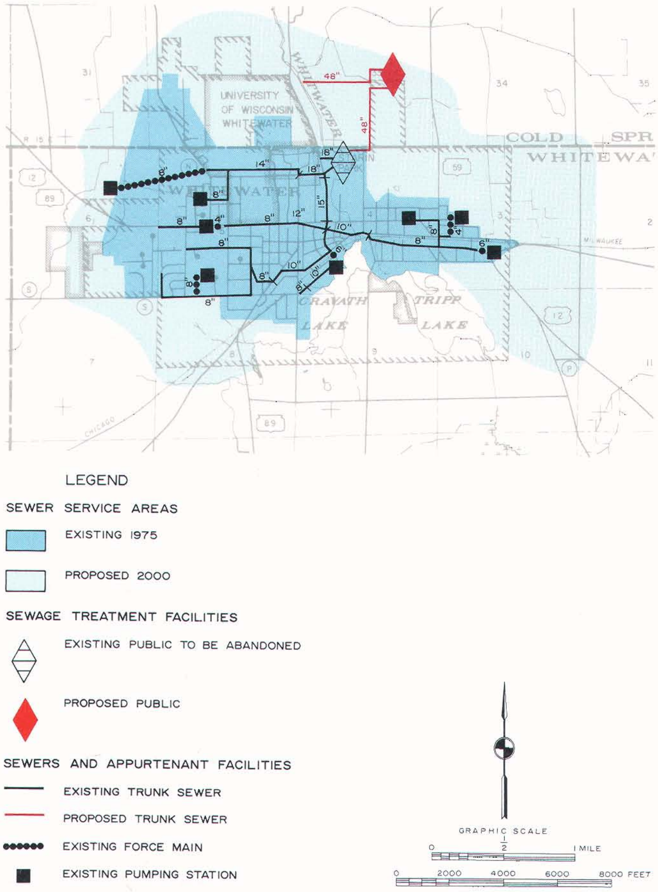
| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Whitewater . . . . . . | $5,216,000 | $398,000 | $3,943,000 | $5,961,000 | $9,904,000 | $250,000 | $378,000 | $628,000 |
| Trunk Sewer | | | | | | | | |
| City of Whitewater . . . . . . | 643,000 | 400 | 403,000 | 5,000 | 408,000 | 25,600 | 300 | 25,900 |
| Total | $5,859,000 | $398,400 | $4,346,000 | $5,966,000 | $10,312,000 | $275,600 | $378,300 | $653,900 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Whitewater | | | | | | | | |
| Facilities. . . . . . . . . . . | $7,473,000 | $229,000 | $5,430,000 | $3,512,000 | $8,942,000 | $344,000 | $223,000 | $567,000 |
| Land . . . . . . . . . . . . . | 900,000 | - - | 516,000 | - - | 516,000 | 33,000 | - - | 33,000 |
| Subtotal | $8,373,000 | $229,000 | $5,946,000 | $3,512,000 | $9,458,000 | $377,000 | $223,000 | $600,000 |
| Trunk Sewer | | | | | | | | |
| City of Whitewater . . . . . . | 643,000 | 400 | 403,000 | 5,000 | 408,000 | 25,600 | 300 | 25,900 |
| Total | $9,016,000 | $229,400 | $6,349,000 | $3,517,000 | $9,866,000 | $402,600 | $223,300 | $625,900 |

[a] *This alternative does not include the cost of additional facilities related to the increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the additional sludge-handling and -disposal requirements is $1,618,000. The estimated capital cost for construction of the added sludge facilities is $980,000, with an estimated average annual operation and maintenance cost of $53,000 over the design period 1975-2000.*

*Source: SEWRPC.*

Map 95

ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE WHITEWATER SEWER SERVICE AREA— LOWER ROCK RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the Whitewater treatment facility be relocated to a new site, about 0.5 mile north of the existing plant site, and that it be expanded and upgraded to serve the year 2000 sewer service area. In order to meet the established water use objectives for Whitewater Creek, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of the plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Whitewater Creek. Both the treatment and discharge alternative and the land application alternative were considered. The treatment and discharge alternative is proposed because it more closely reflects the locally developed plans which are in the process of being implemented.

*Source: SEWRPC.*

arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 1,000 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management.

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of the wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters. However, as previously noted, local facilities planning work has been completed, with construction expected to begin in 1979 for most of the components for treatment and discharge to surface waters. Because of the findings of this local study, and because of the existing stage of implementation, Alternative Plan 1—the provision of advanced waste treatment followed by discharge to the surface waters—is recommended.

Alternative Plans—Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien Subareas

As previously noted, the interconnection of the Delavan, Delavan Lake, Walworth County Institutions, and Elkhorn sewer service areas had been recommended in the regional sanitary sewerage system plan. In addition, it was recommended that the Village of Darien continue operating its public wastewater treatment facility, which incorporates a soil absorption system. It was further recommended that the soil absorption system be monitored and that if, at some future date, studies conclude that soil absorption is no longer a feasible means of waste disposal, reconsideration be given to potential interconnections to other wastewater treatment systems.

The Walworth County Metropolitan Sewerage District has completed facilities planning for a new areawide wastewater treatment facility at the site of the existing City of Delavan wastewater treatment plant on Turtle Creek. The new plant is proposed to provide wastewater treatment for the Cities of Delavan and Elkhorn, the Delavan Lake Sanitary District, and the Walworth County Institutions. The plant is proposed to have an average hydraulic design capacity of 3.6 mgd, and is to provide secondary and tertiary waste treatment, with advanced waste treatment for nitrification and auxiliary waste treatment for effluent aeration and disinfection. In view of the existing stage of implementation of the proposed plan for the District, the decision to construct the proposed new wastewater treatment plant at the site of the existing Delavan wastewater treatment plant, with discharge of the plant effluent to surface waters, has been treated as a committed decision for the Lower Rock River subregional area.

The Village of Darien has initiated a facilities planning program to evaluate the current wastewater treatment facilities' problems and the future wastewater treatment and conveyance needs of the community. The soil absorption system presently incorporated into the village wastewater treatment system does not have the capacity to handle the existing plant loading, and thus plant effluent is discharged to a tributary of Little Turtle Creek.

In order to meet established water use objectives for Turtle Creek, the treatment plants proposed under each of the two alternative plans considered will need to provide either a secondary level of wastewater treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection. The Delavan facility would discharge to Turtle Creek and the Darien facility would discharge to a tributary of Little Turtle Creek. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan. That plan recommended the provision of secondary waste treatment plus conventional advanced waste treatment for nitrification and phosphorus removal—with an effluent with a concentration of 1.0 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection at the recommended areawide treatment plant serving the Delavan, Delavan Lake, Elkhorn, and the Walworth County Institutions sewer service areas. For the treatment plant serving the Darien sewer service area, the regional sanitary sewerage system plan recommended the provision of secondary waste treatment plus auxiliary waste treatment for effluent disinfection followed by soil absorption.

Based upon the general analyses described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application would be less costly than providing secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for plants the size of the Darien facility. Thus, the areawide water quality management plan for the alternative considering continued operation of the Darien treatment plant to serve the Darien sewer service area is based upon the effluent land application alternative, but recognizes the need for more detailed local facility planning to examine alternatives providing for surface water discharge as well as the land application alternative. As previously noted, the treatment and discharge alternative has been considered a committed decision for the areawide treatment plant at Delavan.

Two alternative sanitary sewerage plans were formulated for the Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas. The first plan provides for a separate treatment facility to serve the Darien sewer service area and the construction of a new areawide wastewater treatment plant to serve the Delavan, Delavan Lake, Walworth County Institutions, and Elkhorn sewer service areas. The second alternative provides for the abandonment of the Darien wastewater treatment plant and the connection of the Darien sewer service area to the proposed areawide plant at Delavan. Proposed sewage treatment levels and performance standards under the two alternatives are set forth in Table 214, and the two proposals are shown on Maps 96 and 97.

Under Alternative Plan 1, the existing Darien wastewater treatment plant would be expanded and upgraded to serve the Darien sewer service area. In 1975 the wastewater treatment facility serving the Village of Darien sewer service area had an average hydraulic design capacity of 0.15 mgd, and provided a secondary level of treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Darien sewer service area of about 0.22 mgd in 1985 and about 0.35 mgd in the year 2000. This year 2000 design flow is the same as that anticipated under the regional sanitary sewerage system plan. Under Alternative Plan 1, a new wastewater treatment plant would also be constructed at the site of the existing Delavan facility to serve the Delavan, Delavan Lake, Walworth County Institutions, and Elkhorn sewer service areas, with the subsequent abandonment of the Elkhorn plant. It is anticipated that future growth, along with the construction of new trunk sewers to convey wastewater from the Delavan Lakes and Elkhorn sewer service areas, will require an average hydraulic design capacity for the Delavan-Elkhorn facility of about 3.26 mgd in 1985 and about 4.08 mgd in the year 2000. This year 2000 design flow is about the same as the estimated 1990 flow of 4.17 mgd anticipated under the regional sanitary sewerage system plan.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas is about $20,256,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $14,581,000, with an estimated average annual operation and maintenance cost of $672,000 (see Table 215).

Under Alternative Plan 2, the new areawide facility at Delavan would be designed to serve Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien. The existing Darien facility would be abandoned, and a trunk sewer would be constructed to convey wastewater from Darien to Delavan.

The total present worth over a 50-year analysis period of construction and operation of the recommended treatment and conveyance facilities included under Alternative Plan 2 for the Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas is about $18,763,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $13,353,000, with an estimated average annual operation and maintenance cost of $630,000 (see Table 215).

On an equivalent annual basis, the cost of implementing Alternative Plans 1 and 2 is relatively close—within about 8 percent. Thus, plan selection should also be based upon other less tangible, but nevertheless real, con-

Table 214

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE DELAVAN, DELAVAN LAKE, ELKHORN, WALWORTH COUNTY INSTITUTIONS, AND DARIEN SEWER SERVICE AREAS: LOWER ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| City of Delavan | 3.26 | 4.08 | Delavan, Delavan Lake, Elkhorn, Walworth County Institutions | 19,400 | 23,200 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Effluent Aeration<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Village of Darien | 0.22 | 0.35 | Darien | 1,400 | 2,000 | Secondary<br>Auxiliary<br>Advanced | Activated Sludge<br>Disinfection<br>Land Application | $BOD_5$ Discharge: 15.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml<br>- - |
| Alternative Plan 2 | | | | | | | | |
| City of Delavan | 3.48 | 4.43 | Delavan, Delavan Lake, Elkhorn, Darien, Walworth County Institutions | 20,800 | 25,200 | Secondary<br>Advanced<br><br>Auxiliary | Activated Sludge<br>Nitrification<br>Phosphorus Removal<br>Effluent Aeration<br>Disinfection | $BOD_5$ Discharge: 15.0 mg/l<br>Ammonia-Nitrogen Discharge: 1.5 mg/l<br>Phosphorus Discharge: 0.1 mg/l[b]<br>Dissolved Oxygen in Effluent: 6.0 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

[a] *See Map 89.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Turtle Creek.*

*Source: SEWRPC.*

siderations. Alternative Plan 2 has the advantage of providing only one treatment facility to serve the Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas, thus avoiding the duplication of staff and related facilities associated with two plants. The monitoring requirements associated with the treatment facilities would also be less under Alternative Plan 2. However, Alternative Plan 2 has an inherent disadvantage in that it requires the conveyance of wastewater from the Darien sewer service area to the Delavan sewer service area. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1. Alternative Plan 1 could be more readily implemented since this alternative represents a continuation of existing or planned practices. Under Alternative Plan 2, additional pumping, with its associated energy use, would be required to convey wastes from the Darien sewer service area to the Delavan sewer service area. Based upon all of these considerations, no alternative is clearly better. However, on the basis of lower energy use for wastewater conveyance, lower construction requirements, and ease of implementation, Alternative Plan 1—two wastewater treatment plants to serve the Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas—is proposed.

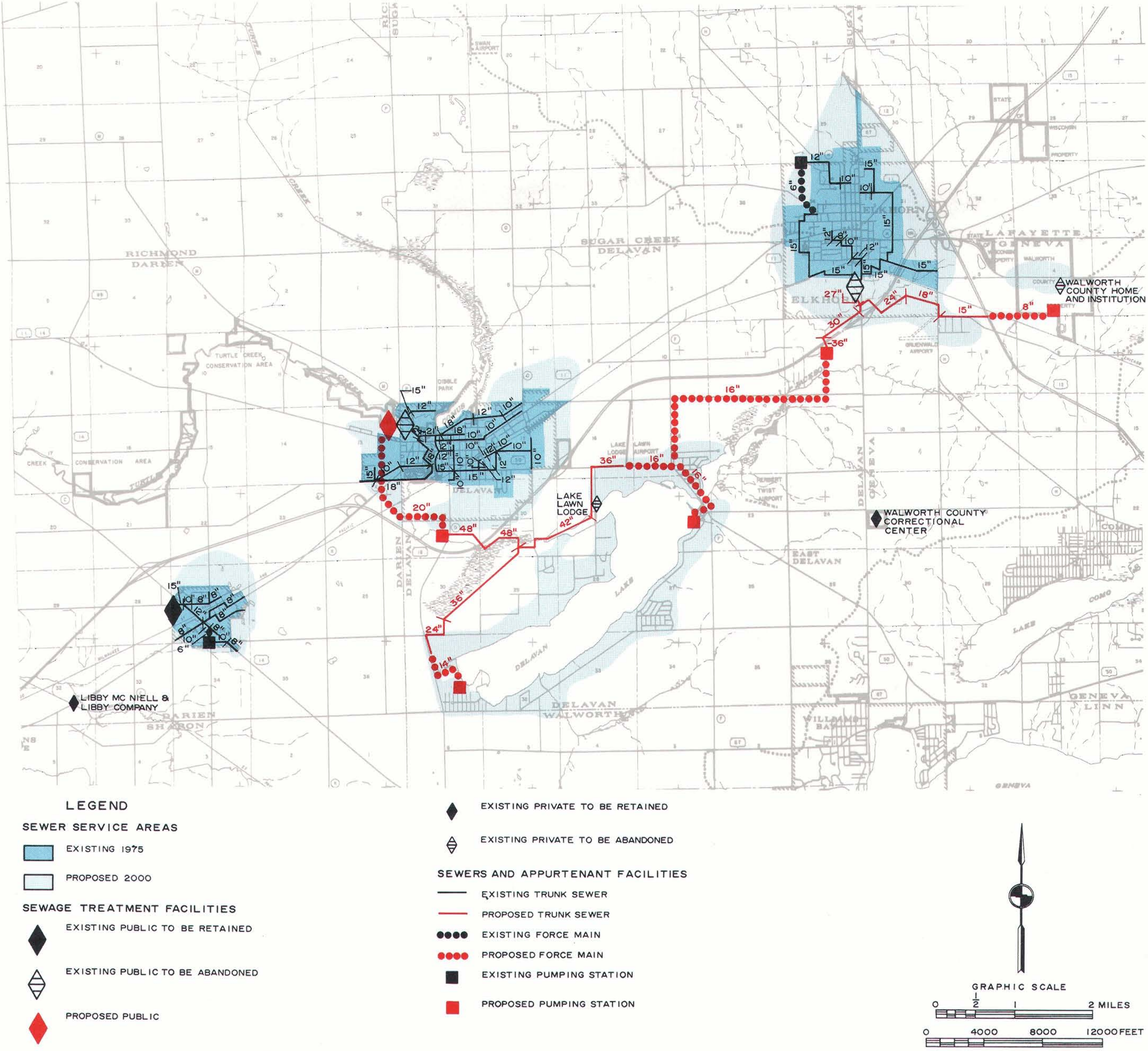
It is proposed that the Darien facility utilize secondary treatment followed by land application of plan effluent. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l.

Alternative Plans—Fontana, Walworth, and Williams Bay Subareas

In 1975 the wastewater treatment facilities serving these three sewer service areas had a combined average hydraulic capacity of 1.8 mgd, and each provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the combined Fontana, Walworth, and Williams Bay sewer service areas of about 2.40 mgd

Map 96

## ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 1 FOR THE DELAVAN, DELAVAN LAKE, ELKHORN, WALWORTH COUNTY INSTITUTIONS, AND DARIEN SEWER SERVICE AREAS—LOWER ROCK RIVER SUBREGIONAL AREA: 2000

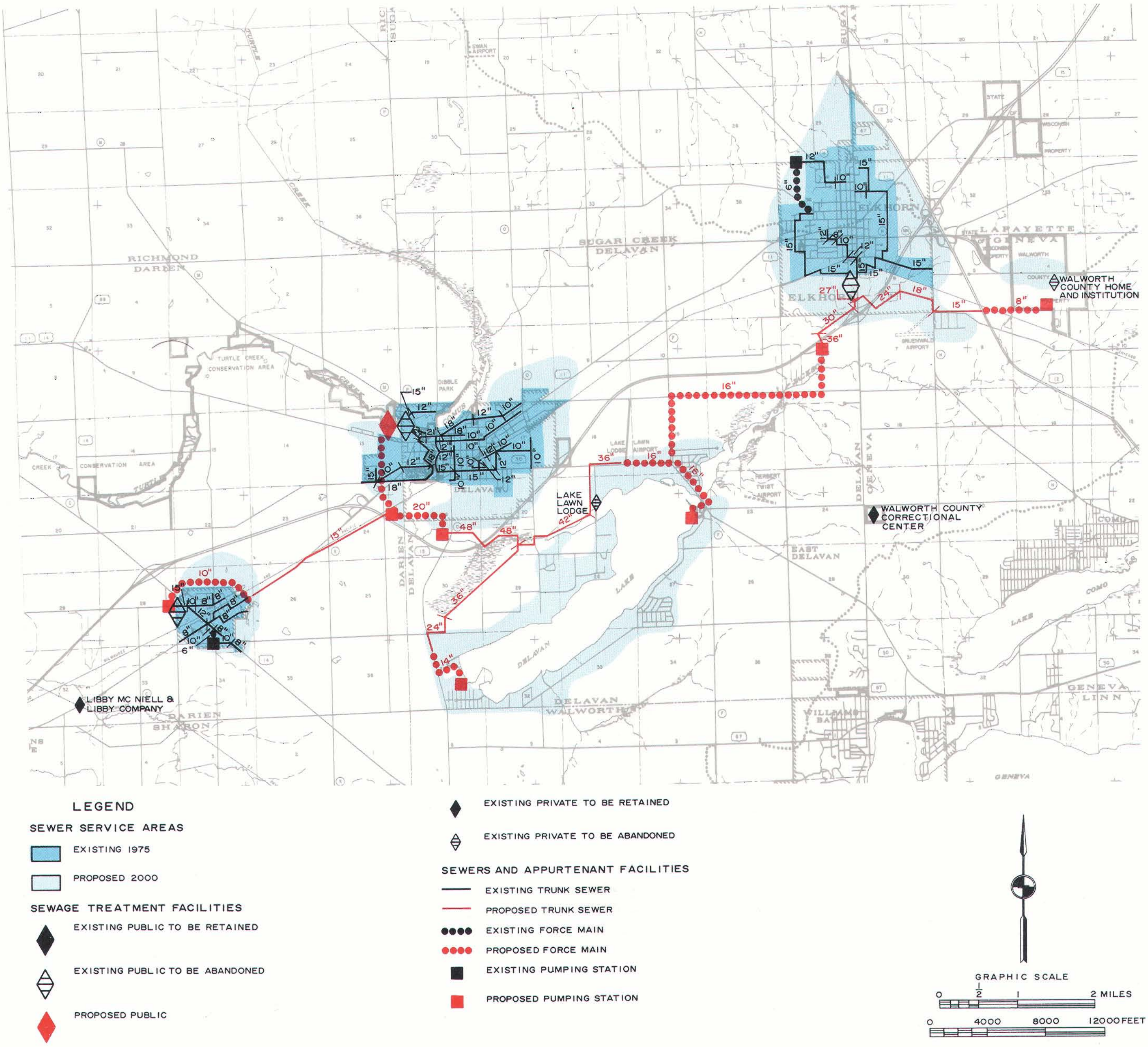



The first alternative plan considered for the Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas proposes the construction of a new wastewater treatment facility to serve Delavan, Delavan Lake, Walworth County Institutions, and Elkhorn sewer service areas. This facility would be operated by the Walworth County Metropolitan Sewerage District and would provide secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection. Alternative Plan 1 also proposes the construction of trunk sewers to convey wastewater from the Delavan Lake, Elkhorn, and Walworth County Institutions sewer service areas to the new areawide facility at Delavan. Under the alternative, the existing Elkhorn wastewater treatment plant would be abandoned, and the existing Darien wastewater treatment plant would be expanded and upgraded to serve the Darien sewer service area. This facility would provide secondary waste treatment followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment.

*Source: SEWRPC.*

Map 97

## ALTERNATIVE SANITARY SEWERAGE SYSTEM PLAN 2 FOR THE DELAVAN, DELAVAN LAKE, ELKHORN, WALWORTH COUNTY INSTITUTIONS, AND DARIEN SEWER SERVICE AREAS—LOWER ROCK RIVER SUBREGIONAL AREA: 2000




The second alternative plan considered for the Delavan, Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas proposes the consolidation of wastewater treatment for all these areas at a new treatment facility to be constructed at the site of the existing Delavan wastewater treatment plant. This facility would be operated by the Walworth County Metropolitan Sewerage District and would provide secondary waste treatment with conventional waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Turtle Creek. This alternative also proposes the construction of trunk sewers to convey wastewater from the Delavan Lake, Elkhorn, Walworth County Institutions, and Darien sewer service areas to the new areawide facility at Delavan. Under this alternative, the existing Elkhorn and Darien wastewater treatment plants would be abandoned.

*Source: SEWRPC.*

**Table 215**

**DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE DELAVAN, DELAVAN LAKE, ELKHORN, WALWORTH COUNTY INSTITUTIONS, AND DARIEN SEWER SERVICE AREAS: LOWER ROCK RIVER SUBREGIONAL AREA**

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1 | | | | | | | | |
| Wastewater Treatment Plants | | | | | | | | |
| City of Delavan . . . . . . . . . . . . | $ 6,614,000 | $556,000 | $ 5,002,000 | $8,268,000 | $13,270,000 | $317,000 | $525,000 | $ 842,000 |
| Village of Darien | | | | | | | | |
| Facilities. . . . . . . . . . . . . . . | 1,927,000 | 76,000 | 1,483,000 | 1,217,000 | 2,700,000 | 94,000 | 77,000 | 171,000 |
| Land . . . . . . . . . . . . . . . . . | 144,000 | - - | 83,000 | - - | 83,000 | 5,000 | - - | 5,000 |
| Darien Subtotal | $ 2,071,000 | $ 76,000 | $ 1,566,000 | $1,217,000 | $ 2,783,000 | $ 99,000 | $ 77,000 | $ 176,000 |
| Subtotal—Treatment Plants | $ 8,685,000 | $634,000 | $ 6,568,000 | $9,485,000 | $16,053,000 | $416,000 | $602,000 | $1,018,000 |
| Trunk Sewers | | | | | | | | |
| Walworth County Institutions. . . . | $ 935,000 | $ 5,000 | $ 587,000 | $ 66,000 | $ 653,000 | $ 37,000 | $ 4,000 | $ 41,000 |
| Delavan Lake Sanitary District . . . | 1,436,000 | 16,000 | 901,000 | 208,000 | 1,109,000 | 57,000 | 13,000 | 70,000 |
| Delavan Lake . . . . . . . . . . . . . | 3,525,000 | 17,000 | 2,212,000 | 229,000 | 2,441,000 | 140,000 | 15,000 | 155,000 |
| Subtotal | $ 5,896,000 | $ 38,000 | $ 3,700,000 | $ 503,000 | $ 4,203,000 | $234,000 | $ 32,000 | $ 266,000 |
| Total | $14,581,000 | $672,000 | $10,268,000 | $9,988,000 | $20,256,000 | $650,000 | $634,000 | $1,284,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| City of Delavan . . . . . . . . . . . . | $ 6,945,000 | $584,000 | $ 5,250,000 | $8,726,000 | $14,010,000 | $333,000 | $553,000 | $ 886,000 |
| Trunk Sewers | | | | | | | | |
| Walworth County Institutions. . . . | 935,000 | 5,000 | 587,000 | 66,000 | 653,000 | 37,000 | 4,000 | 41,000 |
| Delavan Lake Sanitary District . . . | 1,436,000 | 16,000 | 901,000 | 208,000 | 1,109,000 | 57,000 | 13,000 | 70,000 |
| Delavan Lake . . . . . . . . . . . . . | 3,525,000 | 17,000 | 2,212,000 | 229,000 | 2,441,000 | 140,000 | 15,000 | 155,000 |
| Darien to Delavan. . . . . . . . . . . | 512,000 | 8,000 | 438,000 | 112,000 | 550,000 | 28,000 | 71,000 | 99,000 |
| Subtotal | $ 6,408,000 | $ 46,000 | $ 4,138,000 | $ 615,000 | $ 4,753,000 | $262,000 | $103,000 | $ 365,000 |
| Total | $13,353,000 | $630,000 | $ 9,388,000 | $9,341,000 | $18,763,000 | $595,000 | $656,000 | $1,251,000 |

*Source: SEWRPC.*

in 1985 and about 3.12 mgd in the year 2000. This year 2000 design flow is the same as the 3.12 mgd combined capacity anticipated under the regional sanitary sewerage system plan.

As previously noted, in 1978 the Villages of Fontana, Walworth, and Williams Bay, in conjunction with other communities in the Lake Geneva area, had completed local facilities planning to determine existing and future wastewater treatment and conveyance needs for the sewer service areas around Lakes Geneva and Como. The local facility planning study recommended that the Lake Geneva wastewater treatment plant be expanded and upgraded to serve the Lake Geneva and Lake Como areas. The local facility plan further recommends, after consideration of several alternatives, that the Villages of Fontana and Williams Bay, together with adjacent urban development along the north and south shorelines of Lake Geneva, be served through a proposed new areawide Village of Walworth treatment facility.

The local facilities plan recommended one revision to the sewer service area boundary delineation included in the regional sanitary sewerage system plan. The local facilities plan proposes that sanitary sewer service be extended from the Lake Geneva wastewater treatment plant along the southern shoreline of Lake Como to the Interlaken Resort area at the western end of the lake, thus permitting the abandonment of the existing Interlaken Resort wastewater treatment plant. In the regional sanitary sewerage system plan, this abandonment was recommended to be effected through a sewer service extension from the Village of Williams Bay. The sewer service area delineations included herein have been refined to reflect the minor adjustment in the sewer service area recommended in the local facility plan.

In view of the findings of the local facility plan, no further alternative analyses have been conducted with regard to the number and location of treatment facilities for the sewer service areas around Lake Geneva and

Lake Como. With regard to the treatment facilities serving the sewer service areas in the Lower Rock River subregional area, it is recommended that the Walworth facility provide centralized wastewater treatment service for the Fontana, Walworth, and Williams Bay sewer service areas. Further local facilities planning steps are being planned to determine the final type of treatment to be utilized at the Walworth treatment facility and the precise location of that facility.

In order to meet established water use objectives for Piscasaw Creek, the Walworth facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide water quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

As noted in the analysis described earlier in this chapter, the effluent land application alternative and treatment and discharge alternative should be considered further for a plant the size of the proposed Walworth facility. Accordingly, two treatment alternatives were considered for the Fontana, Walworth, and Williams Bay sewer service areas. The first alternative would provide for continued discharge of the Walworth wastewater treatment plant effluent to Piscasaw Creek following the required levels of advanced and auxiliary waste treatment. The second alternative assumes the provision of a land application system for disposal of secondary treatment plant effluent from the Walworth wastewater treatment facility. The recommended wastewater treatment plant performance standards for both of the alternatives are set forth in Table 216, and the proposal for each alternative is shown on Map 98.

The first alternative is based upon the provision of secondary waste treatment with advanced waste treatment for ammonia-nitrogen and phosphorus removal utilizing conventional chemical treatment for phosphorus removal, biological nitrification, two-stage chemical clarification, multimedia filtration, and chlorination prior to discharge of effluent to Piscasaw Creek. The total present worth over a 50-year analysis period of construction and operation the proposed treatment and conveyance facilities included under Alternative Plan 1 for the Fontana, Walworth, and Williams Bay sewer service areas is about $13,288,000. The estimated capital cost for constructing the necessary additional treatment and

*Table 216*

**WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE FONTANA, WALWORTH, AND WILLIAMS BAY SEWER SERVICE AREAS: LOWER ROCK RIVER SUBREGIONAL AREA**

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Areas Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Alternative Plan 1 | | | | | | | | |
| Village of Walworth | 2.40 | 3.12 | Fontana, Walworth, Williams Bay | 11,800 | 15,500 | Secondary | Activated Sludge | $BOD_5$ Discharge: 15.0 mg/l |
| | | | | | | Auxiliary | Disinfection | Fecal Coliform Concentration: 200/100 ml |
| | | | | | | Advanced | Land Application[b] | - - |
| Alternative Plan 2 | | | | | | | | |
| Village of Walworth | 2.40 | 3.12 | Fontana, Walworth, Williams Bay | 11,800 | 15,500 | Secondary | Activated Sludge | $BOD_5$ Discharge: 15.0 mg/l |
| | | | | | | Advanced | Nitrification | Ammonia-Nitrogen Discharge: 1.5 mg/l |
| | | | | | | | Phosphorus Removal | Phosphorus Discharge: 0.1 mg/l[b] |
| | | | | | | Auxiliary | Disinfection | Fecal Coliform Concentration: 200/100 ml |
| | | | | | | | Aeration | Dissolved Oxygen in Effluent: 6.0 mg/l |

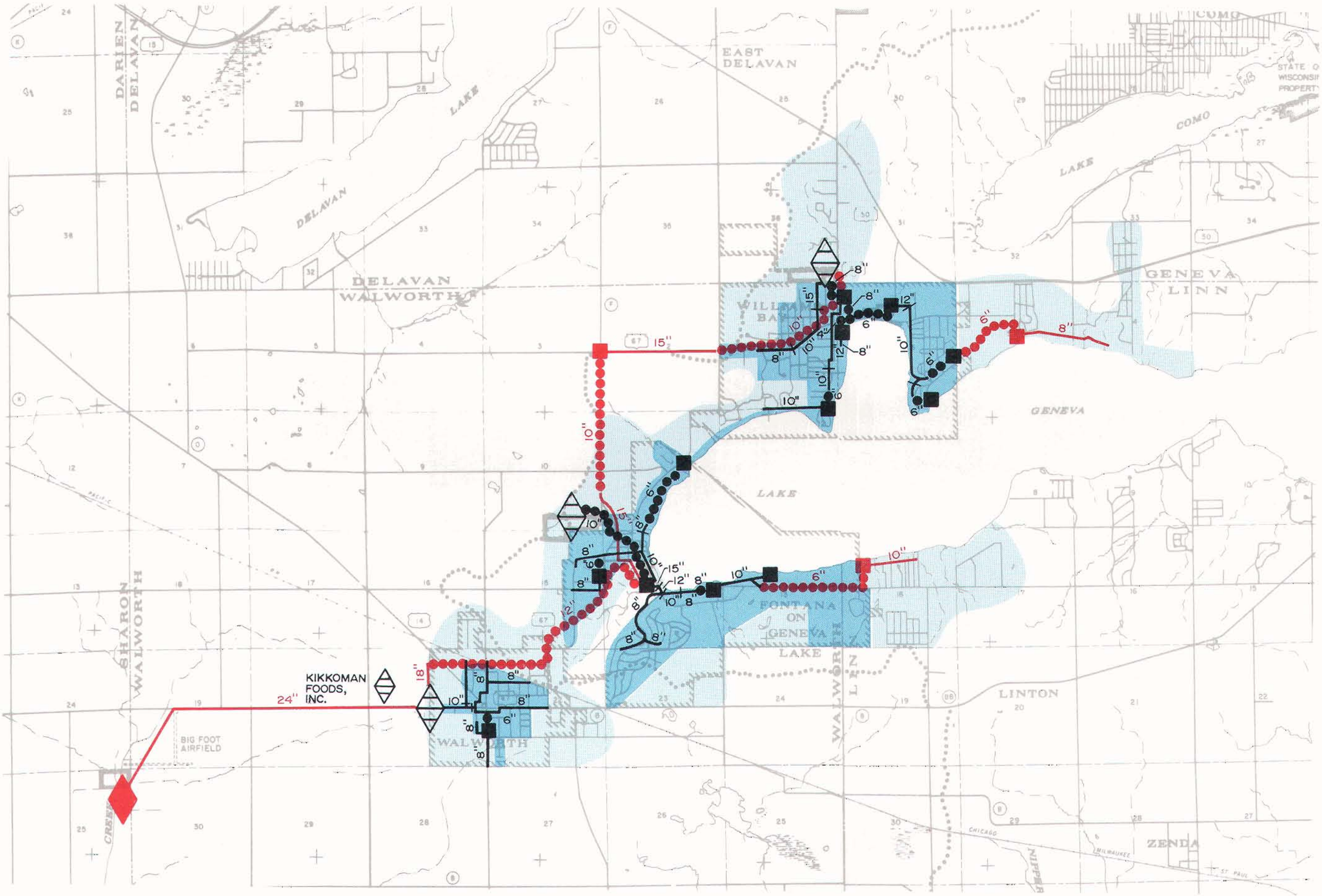
[a] *See Map 94.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment followed by conventional advanced waste treatment for nitrification and phosphorus removal (effluent concentration of 1.0 mg/l of total phosphorus) and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Piscasaw Creek.*

*Source: SEWRPC.*

Map 98

# ALTERANTIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE FONTANA, WALWORTH, AND WILLIAMS BAY SEWER SERVICE AREAS—LOWER ROCK RIVER SUBREGIONAL AREA: 2000




LEGEND

SEWER SERVICE AREAS

EXISTING 1975

PROPOSED 2000

SEWAGE TREATMENT FACILITIES

EXISTING PUBLIC TO BE ABANDONED

PROPOSED PUBLIC

EXISTING PRIVATE TO BE ABANDONED

SEWERS AND APPURTENANT FACILITIES

EXISTING TRUNK SEWER

PROPOSED TRUNK SEWER

EXISTING FORCE MAIN

PROPOSED FORCE MAIN

EXISTING PUMPING STATION

PROPOSED PUMPING STATION

GRAPHIC SCALE

0 ½ 1 2 MILES

0 2,000 4,000 8,000 12,000 FEET

The areawide water quality management plan proposes that the Walworth treatment facility be relocated west of the existing facility near the Piscasaw Creek and that this plant be designed to provide wastewater treatment for the Fontana, Walworth, and Williams Bay sewer service areas. In order to meet the established water use objectives for Piscasaw Creek, this facility will need to provide either secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application of plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection prior to discharge to Piscasaw Creek. Both alternative methods of waste treatment were examined under the areawide plan. Each alternative provided for trunk sewers to convey wastes from the Fontana and Williams Bay sewer service area to the proposed areawide Walworth treatment facility. The analysis indicated that land application of plant effluent is a viable alternative to treatment and discharge to the surface waters.

*Source: SEWRPC.*

conveyance facilities is $10,096,000, with an estimated average annual operation and maintenance cost of $427,000 (see Table 217).

The second alternative treatment system is based upon the provision of secondary waste treatment with auxiliary waste treatment for effluent disinfection followed by land application. For areawide systems level analysis purposes, rural land in the Town of Walworth was selected to receive the effluent from the Walworth wastewater treatment facility. This site would be relatively close to the treatment facility. The total present worth over a 50-year analysis period for construction and operation of the recommended treatment and conveyance facilities included under Alternative Plan 2 for the Fontana, Walworth, and Williams Bay sewer service areas is about $13,006,000. The estimated capital cost for constructing the necessary additional treatment and conveyance facilities is $13,084,000, with an estimated average annual operation and maintenance cost of $278,000 (see Table 217).

On an equivalent annual cost basis, including the cost associated with the sludge-related facilities required under the first alternative, Alternative Plan 1 would be about 13 percent more costly to implement than would Alternative Plan 2. However, there are other less tangible, but nevertheless real, factors which should be considered. Alternative Plan 1 could be more readily accomplished, since this alternative represents a continuation of existing practices with the added construction and operational requirements associated with the recommended expansion and upgraded level of treatment. Because of the land requirements for land application under Alternative Plan 2, it would be difficult to select and acquire sites or make other institutional arrangements for the use of agricultural land, and thus this alternative would be difficult to implement. In addition, Alternative Plan 2 requires the commitment of approximately 1,200 acres of land, which would result in a major change in agricultural land management for the selected application site area, and requires that treatment plant managers become involved in agricultural land management.

Table 217

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—ALTERNATIVE SANITARY SEWERAGE SYSTEM PLANS FOR THE FONTANA, WALWORTH, AND WILLIAMS BAY SEWER SERVICE AREAS: LOWER ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Alternative Plan 1[a] | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Walworth | $ 5,073,000 | $382,000 | $3,836,000 | $5,705,000 | $ 9,541,000 | $243,000 | $362,000 | $605,000 |
| Trunk Sewers | | | | | | | | |
| Williams Bay-Lake Geneva | 326,000 | 11,000 | 205,000 | 139,000 | 344,000 | 13,000 | 9,000 | 22,000 |
| Williams Bay-Fontana | 1,469,000 | 15,000 | 922,000 | 195,000 | 1,117,000 | 58,000 | 12,000 | 70,000 |
| Fontana-Lake Geneva | 1,342,000 | 10,000 | 842,000 | 136,000 | 978,000 | 53,000 | 9,000 | 62,000 |
| Fontana-Walworth | 1,135,000 | 8,000 | 712,000 | 112,000 | 824,000 | 45,000 | 7,000 | 52,000 |
| Walworth | 751,000 | 1,000 | 471,000 | 13,000 | 484,000 | 30,000 | 1,000 | 31,000 |
| Subtotal | $ 5,023,000 | $ 45,000 | $3,152,000 | $ 595,000 | $ 3,747,000 | $199,000 | $ 38,000 | $237,000 |
| Total | $10,096,000 | $427,000 | $6,988,000 | $6,300,000 | $13,288,000 | $442,000 | $400,000 | $842,000 |
| Alternative Plan 2 | | | | | | | | |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Walworth | | | | | | | | |
| Facilities | $ 7,206,000 | $233,000 | $5,234,000 | $3,535,000 | $ 8,769,000 | $332,000 | $224,000 | $556,000 |
| Land | 855,000 | -- | 490,000 | -- | 490,000 | 31,000 | -- | 31,000 |
| Subtotal | $ 8,061,000 | $233,000 | $5,724,000 | $3,535,000 | $ 9,259,000 | $363,000 | $224,000 | $587,000 |
| Trunk Sewers | | | | | | | | |
| Williams Bay-Lake Geneva | 326,000 | 11,000 | 205,000 | 139,000 | 344,000 | 13,000 | 9,000 | 22,000 |
| Williams Bay-Fontana | 1,469,000 | 15,000 | 922,000 | 195,000 | 1,117,000 | 58,000 | 12,000 | 70,000 |
| Fontana-Lake Geneva | 1,342,000 | 10,000 | 842,000 | 136,000 | 978,000 | 53,000 | 9,000 | 62,000 |
| Fontana-Walworth | 1,135,000 | 8,000 | 712,000 | 112,000 | 824,000 | 45,000 | 7,000 | 52,000 |
| Walworth | 751,000 | 1,000 | 471,000 | 13,000 | 484,000 | 30,000 | 1,000 | 31,000 |
| Subtotal | $ 5,023,000 | $ 45,000 | $3,152,000 | $ 595,000 | $ 3,747,000 | $199,000 | $ 38,000 | $237,000 |
| Total | $13,084,000 | $278,000 | $8,876,000 | $4,130,000 | $13,006,000 | $562,000 | $262,000 | $824,000 |

[a] *This alternative does not include the cost of additional facilities related to the increased sludge production associated with the higher degree of treatment required under Alternative Plan 1. The total present worth over a 50-year analysis period of the additional sludge-handling and -disposal facilities is $1,663,000. The estimated capital cost for construction of these added sludge-related facilities is $1,214,000, with an estimated average annual operation and maintenance cost of $51,000 over the design period 1975-2000.*

*Source: SEWRPC.*

Alternative Plan 2 also requires the construction of a conveyance system to transport treatment plant effluent to the land application site. Thus, Alternative Plan 2 would have a greater environmental impact and would affect more area and a greater population than would Alternative Plan 1.

Although there would be a greater wastewater pumping requirement under Alternative Plan 2 for conveyance of wastewater to the land application site, it would require less energy than would Alternative Plan 1 because of the energy requirement associated with the higher level of treatment needed under Alternative Plan 1. Alternative Plan 2 also offers advantages in that nutrients would be recycled from wastewater back to the agricultural land, and the treatment plant discharge of pollutants would be completely eliminated from the surface waters.

Based upon the above considerations, neither alternative is clearly better. However, the areawide water quality management plan is based upon the land application alternative, but recognizes the need for more detailed local facilities planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to the Piscasaw Creek should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l.

Proposed Plan—Sharon Subarea

In 1975 the wastewater treatment facility serving the Village of Sharon and its environs had an average hydraulic design capacity of about 0.15 mgd, and provided a secondary level of waste treatment. It is anticipated that future growth will require an average hydraulic design capacity for the Sharon sewer service area of about 0.19 mgd in 1985 and about 0.33 mgd in the year 2000. This year 2000 design flow is somewhat lower than the estimated 1990 design flow of 0.55 mgd anticipated under the regional sanitary sewerage system plan. The Village is presently in the process of preparing a facility plan to evaluate future wastewater treatment and conveyance needs.

In order to meet established water use objectives for Sharon Creek, a tributary of the Rock River, this facility will need to provide either a secondary level of treatment with auxiliary waste treatment for effluent disinfection followed by land application of treatment plant effluent, or secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal—producing an effluent with a concentration of approximately 0.1 mg/l of total phosphorus—and auxiliary waste treatment for effluent aeration and disinfection. The recommendations concerning treatment and discharge to surface waters differ from those contained in the regional sanitary sewerage system plan only with regard to the level of phosphorus removal which should be achieved. That plan recommended that plant effluent have a total phosphorus concentration of 1.0 mg/l, while the recommendations of the areawide quality management planning program are based upon an effluent total phosphorus concentration of about 0.1 mg/l.

Based upon the general analysis described earlier in this chapter, the provision of secondary waste treatment followed by auxiliary waste treatment for effluent disinfection and land application would be less costly than providing secondary waste treatment with conventional advanced waste treatment for nitrification, a high level of advanced waste treatment for phosphorus removal, and auxiliary waste treatment for effluent aeration and disinfection for treatment plants the size of the Sharon facility. Thus, the areawide water quality management plan is based upon the land application, but recognizes the need for more detailed facilities planning to examine alternatives providing for surface water discharge as well as the land application alternative. Should local facilities planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with effluent discharge to surface waters should be considered. That alternative treatment system should be designed to initially reduce phosphorus to the lowest practical level, and to ultimately reduce the total phosphorus concentration in the effluent to about 0.1 mg/l. The recommended performance standards for the Sharon wastewater treatment plant are set forth in Table 218, and the proposal is shown on Map 99.

The total present worth over a 50-year analysis period of construction and operation of the proposed treatment and conveyance facilities for the Sharon sewer service area is about $2,648,000. The estimated capital cost for constructing the necessary additional treatment facilities is $1,957,000, with an estimated average annual operation and maintenance cost of $73,000 (see Table 219).

Private Wastewater Treatment Plants

There are five known private wastewater treatment facilities in the Lower Rock River subregional area which in general serve isolated enclaves of urban land uses and treat wastes which can be accepted in public sanitary sewer systems. These facilities currently discharge relatively minor amounts of treated wastewaters to the streams and groundwater in the Lower Rock River subregional area. These five facilities serve Kikkoman Foods, Inc. processing plant in the Town of Walworth; Lakeland Nursing Home and associated county institutions in the Town of Geneva; the Walworth County Correction Center in the Town of Geneva, which is not presently in operation; Libby, McNeill and Libby, Inc. canning plant in the Town of Darien; and Lake Lawn Lodge in the Town of Delavan. Except for the Libby, McNeill and Libby, Inc. and the Walworth County

Table 218

WASTEWATER TREATMENT LEVELS AND PERFORMANCE STANDARDS—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SHARON SEWER SERVICE AREA: LOWER ROCK RIVER SUBREGIONAL AREA

| Wastewater Treatment Plant | Estimated Average Hydraulic Design Capacity (mgd) | | Sewer Service Analysis Area Served[a] | Estimated Population | | Recommended Wastewater Treatment Levels | Type of Wastewater Treatment Assumed for Cost Analysis Purposes in Plan Preparation | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|---|---|---|
| | 1985 | 2000 | | 1985 | 2000 | | | |
| Village of Sharon | 0.19 | 0.33 | Sharon | 1,900 | 2,600 | Secondary Auxiliary | Activated Sludge Disinfection | $BOD_5$ Discharge: 30 mg/l Fecal Coliform Concentration: 200/100 ml |
| | | | | | | Advanced | Land Application[b] | - - |

[a] *See Map 94.*

[b] *This treatment recommendation differs from the regional sanitary sewerage system plan recommendations, which included the provision of secondary waste treatment with advanced waste treatment for nitrification and phosphorus removal and conventional auxiliary waste treatment for effluent aeration and disinfection prior to the discharge to Sharon Creek.*

*Source: SEWRPC.*

Table 219

DETAILED ECONOMIC ANALYSIS COST ESTIMATES—PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SHARON SEWER SERVICE AREA: LOWER ROCK RIVER SUBREGIONAL AREA

| Plan Subelement | Estimated Cost: 1975-2000 | | Economic Analysis Estimates | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | |
| | Total Capital | Average Annual Operation and Maintenance | Construction | Operation and Maintenance | Total | Construction | Operation and Maintenance | Total |
| Wastewater Treatment Plant | | | | | | | | |
| Village of Sharon | | | | | | | | |
| Facilities. . . . . . . . . . . | $1,825,000 | $73,000 | $1,404,000 | $1,168,000 | $2,572,000 | $89,000 | $74,000 | $163,000 |
| Land . . . . . . . . . . . . . | 132,000 | - - | 76,000 | - - | 76,000 | 5,000 | - - | 5,000 |
| Subtotal | $1,957,000 | $73,000 | $1,480,000 | $1,168,000 | $2,648,000 | $94,000 | $74,000 | $168,000 |
| Trunk Sewers—None | - - | - - | - - | - - | - - | - - | - - | - - |
| Total | $1,957,000 | $73,000 | $1,480,000 | $1,168,000 | $2,648,000 | $94,000 | $74,000 | $168,000 |

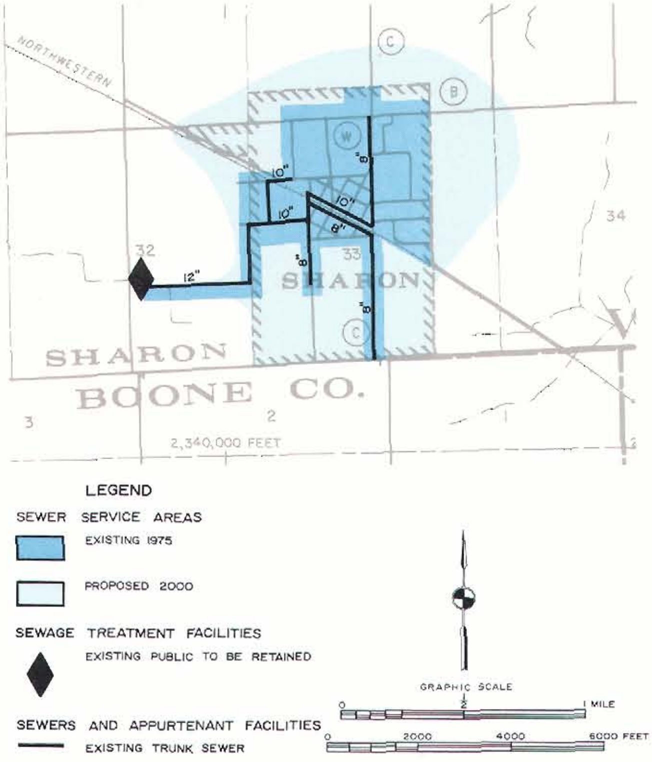
*Source: SEWRPC.*

Correctional Center facilities each of these facilities lies within or very near a proposed year 2000 sewer service area. These three facilities would be abandoned upon implementation of the proposed sewer system plan for the appropriate sewer service area. The remaining facilities should be retained and, as necessary, upgraded to provide a level of treatment adequate to meet the water use objectives and standards for streams within the Rock River watershed. Performance standards are recommended for these two private plants which are consistent with those indicated for public wastewater treatment facilities which discharge to the same receiving waters (see Table 220), but should be refined to reflect specific localized conditions.

Based on the general analysis described earlier in this chapter, effluent land application facilities are considered to be a viable alternative to providing advanced waste treatment and auxiliary waste treatment for facilities the size of the private treatment plants to be retained in the Lower Rock River subregional area. The proposed plan for these plants is based upon the provision of land application of plant effluent. Should local facility planning efforts indicate that land application of plant effluent is not practical to implement, then an alternative treatment system designed to ultimately achieve the level of treatment needed to meet water quality standards with the effluent discharge to surface waters should be considered.

Map 99

PROPOSED SANITARY SEWERAGE SYSTEM PLAN FOR THE SHARON SEWER SERVICE AREA— LOWER ROCK RIVER SUBREGIONAL AREA: 2000




The areawide water quality management plan proposes that the existing Sharon wastewater treatment plant be expanded and upgraded to meet anticipated year 2000 needs. In order to meet the established water use objectives for Sharon Creek, this plant will need to provide either land application of plant effluent following the current secondary level of treatment, or secondary waste treatment with a high level of advanced waste treatment for phosphorus removal and auxiliary waste treatment for effluent disinfection prior to discharge to Sharon Creek.

*Source: SEWRPC.*

The estimated present worth of construction and operation of the private wastewater treatment facilities in the Lower Rock River subregional area over a 50-year analysis period is about $1,500,000. The estimated capital cost for constructing the necessary facilities is about $500,000, with an estimated average annual operation and maintenance cost of $87,000.

Existing Unsewered Urban Development Outside the Initially Proposed Sanitary Sewer Service Area

There are five enclaves of unsewered urban development located outside of the proposed year 2000 sewer service area as shown on Map 94. The corresponding urban enclave population in 1975 and 2000 and the distance to the nearest proposed year 2000 sewer service area are listed in Table 221. In a general alternative analysis described earlier in this chapter, the cost of providing public sewerage service to these enclaves of urban development was compared with the cost of continued onsite wastewater treatment. Based upon the results of that analysis, it was concluded that wastewater treatment for these five enclaves should be provided in one of two ways. For certain of the unsewered urban areas, the plan proposes the continued use of onsite wastewater treatment systems coupled with a suitable program for monitoring and maintaining the systems. This plan proposal is generally applicable to areas with soils and lot sizes which are suitable for conventional onsite wastewater treatment systems. Two of the five unsewered urban areas are included in this category—the Town of Darien—Section 23 and Allens Grove in Walworth County.

For the remaining enclaves, the plan proposes the conduct of further site-specific planning to determine the best wastewater management practice. These enclaves, which should consider alternative methods of onsite

Table 220

WASTEWATER TREATMENT PERFORMANCE STANDARDS FOR PRIVATE WASTEWATER TREATMENT FACILITIES IN THE LOWER ROCK RIVER SUBREGIONAL AREA

| Name of Facility | Civil Division Location | Type of Land Use Served | Type of Wastewater | Disposal of Effluent | Recommended Performance Standards in Terms of Effluent Quality (all standards represent average monthly limits) |
|---|---|---|---|---|---|
| Libby, McNeill, and Libby, Inc. | Town of Darien | Industrial | Process and Sanitary | Soil Absorption | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |
| Walworth County Correctional Center | Town of Geneva | Institutional | Sanitary | Soil Absorption | $BOD_5$ Discharge: 30 mg/l<br>Fecal Coliform Concentration: 200/100 ml |

*Source: SEWRPC.*

Table 221

EXISTING URBAN DEVELOPMENT NOT SERVED BY PUBLIC SANITARY SEWERS IN THE LOWER ROCK RIVER SUBREGIONAL AREA BY MAJOR URBAN CONCENTRATION: 2000

| Number[a] | Major Urban Concentration[b] | Estimated Resident Population | | Distance from Year 2000 Sewer Service Area (miles) |
|---|---|---|---|---|
| | | 1975 | 2000 | |
| | Walworth County | | | |
| 1 | Town of Darien—Section 23 | 260 | 217 | 1.0 |
| 2 | Allens Grove | 108 | 98 | 2.3 |
| 3 | Lake Loraine | 302 | 347 | 5.5 |
| 4 | Turtle Lake | 319 | 312 | 3.5 |
| 5 | Whitewater Lake | 523 | 400 | 1.1 |
| Total | | 1,512 | 1,374 | - - |

[a] *See Map 94.*

[b] *Urban development is defined in this context as concentrations of urban land uses within any given U. S. Public Land Survey quarter section that has at least 32 housing units, or an average of one housing unit per five gross acres, and is not served by public sanitary sewers.*

*Source: SEWRPC.*

waste disposal and an intensive inspection and maintenance program for conventional systems, as well as the possibility of connection to the public sanitary sewer service areas, are Loraine Lake, Turtle Lake, and Whitewater Lake, all in Walworth County. In general, areas in this category have soils and lot sizes which are considered unsuitable for conventional methods of onsite wastewater treatment.

Sanitary System Flow Relief Devices

In 1975 there were 10 sanitary sewer system flow relief devices in the Lower Rock River subregional area. The proposed plan recommends that facilities planning efforts include the formulation of plans for the elimination of these sewage flow relief devices.

Other Known Point Sources of Wastewater

There are a total of 13 known point sources of wastewater other than wastewater treatment plants and sewer system flow relief devices in the Lower Rock River subregional area. These other point sources consist primarily of industrial cooling, process, and backwash waters which are discharged without treatment, or following pretreatment, directly to surface waters or to storm sewers tributary to such streams and watercourses. The discharge characteristics of these point sources of wastewater are reported in Chapter III of SEWRPC Technical Report No. 21, Sources of Water Pollution in Southeastern Wisconsin: 1975, and are indicated to contain constituents of five-day biochemical oxygen demand ($BOD_5$), ammonia-nitrogen, phosphorus, and fecal coliform which are generally lower than those established as performance standards for public and private wastewater treatment plants in the Region discharging to the same or similar surface water bodies. Thus, in most cases, no further treatment recommendations were advanced for these other point sources with regard to these constituents. However, it is recommended that these point sources in general reduce discharge temperatures to $89^oF$ or less, oils and grease to less than 10 mg/l, and heavy metals, organics, and other pollutant concentrations to levels required by "Best Available Technology," or as identified on a case-by-case basis under the state permit system process. Reported effluent characteristics for these point sources which could require treatment are noted in Table 222.

The degree of treatment and costs of constructing and operating treatment facilities associated with these point sources of wastewater should be determined on an individual basis in conjunction with other pretreatment requirements for existing discharges to public sanitary sewerage systems. In order to present a complete analysis of the cost of the areawide water quality management planning program for this subregional area, a cost estimate was to be made of the treatment requirements which appeared to be needed from the limited data available on these point sources. However, the costs of these treatment requirements were not estimated because of very small or intermittent flow, or because wastewater characteristics were bordering the recommended levels and it was assumed that low-cost process modifications could be effected to satisfactorily reduce the effluent concentrations.

Table 222

REPORTED EFFLUENT CHARACTERISTICS FOR KNOWN POINT SOURCES OTHER THAN SEWAGE TREATMENT PLANTS AND SEWAGE FLOW RELIEF DEVICES THAT REQUIRE TREATMENT CONSIDERATION— LOWER ROCK RIVER SUBREGIONAL AREA: 1975

| Point Source Discharge | | Average Flow 1975 (mgd) | Receiving Water Body | Constituents Requiring Treatment Consideration[a] |
|---|---|---|---|---|
| Name | Civil Division Location | | | |
| Allied Music Corporation | City of Elkhorn | 0.003 | Soil Absorption | Suspended Solids, Heavy Metals |
| Buncker Ramo Corporation | City of Delavan | 0.004 | Tributary of Swan Creek via Storm Sewer | Heavy Metals |
| Frank Holton and Company | City of Elkhorn | 0.015 | Soil Absorption | Suspended Solids, Heavy Metals |
| Getzen Company | City of Elkhorn | 0.010 | Soil Absorption | Suspended Solids |

[a] *Unless specifically noted otherwise, data were obtained, in order of priority, from: quarterly reports filed with the Wisconsin Department of Natural Resources under the Wisconsin Pollutant Discharge Elimination System or under Section 101 of the Wisconsin Administrative Code, or from the Wisconsin Pollutant Discharge Elimination System permit itself.*

*Source: Wisconsin Department of Natural Resources and SEWRPC.*

## SUMMARY

The design, test, and evaluation of alternative plans is the heart of the planning process. This chapter documents the plan design, test, and evaluation phase of the areawide water quality management planning program. Alternative point source pollution control strategies for each of 11 subregional areas and alternative nonpoint source pollution control levels for the streams within each of the 12 major watersheds in the Region are included. The various pollution abatement strategies and control levels were evaluated for their ability to satisfy the recommended water use objectives and supporting water quality standards as set forth in Chapter II of this volume, with each alternative being designed to support the implementation of the adopted regional land use plan. Alternative water quality management evaluations for each of the 100 major lakes in the Region are presented in Appendix C to this volume, published separately.

Alternative plans were developed and evaluated which incorporated water quality management elements for both point and nonpoint sources of pollutants. As a result of the information set forth in the state-of-the-art studies documented in SEWRPC Technical Report No. 18, and upon previous sewerage system planning experience, it was concluded that the major emphasis in the formulation of alternative point source pollutant abatement strategies should be on conventional sanitary sewerage systems providing the needed levels of treatment at sewage treatment facilities with discharge of treated wastes to land application systems or to surface waters.

In considering the point source pollution abatement measures presented in this chapter, the iterative nature of the water quality management planning process must be recognized. This process consists of successive cycles of areawide systems planning and local project planning efforts, with each cycle of local project planning serving to refine and detail the preceding cycle of systems planning, and each cycle of systems planning building upon preceding cycles of project planning by incorporating the refinements and details of local implementation actions. The recommendations of the adopted regional sanitary sewerage sytem plan, and the resulting development of detailed local facilities plans, represent such a planning cycle. Accordingly, this chapter presents alternative proposals for point source abatement measures where changes since the Commission adoption of the regional sanitary sewerage system plan indicated the need to reconsider such alternatives at the systems level. Alternative proposals for point source abatement were also considered where analyses conducted under the areawide water quality management planning program indicated that higher levels of wastewater treatment are required to satisfy the recommended water use objectives.

Alternatives were also developed with respect to the abatement of pollution from nonpoint, or diffuse, sources based upon cost, implementability, and effectiveness in abating water pollution. Nonpoint pollution control practices were grouped into categories of various levels of nonpoint source control. Certain nonpoint source control measures can be accomplished at minimum cost, with the basic requirement being cooperative efforts by an enlightened public and implementing authorities. These low-cost measures have been combined with others considered to be needed for sound land management and water quality protection as a set of practices recommended for general application throughout the Region. In urban areas, these low-cost and basic nonpoint pollution abatement practices include public education programs; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; litter and pet waste control; proper use of fertilizers and pesticides; construction erosion controls; septic tank system management; critical area protection; and industrial and commercial material storage facilities and runoff control. In rural areas, these minimum practices include fertilizer and pesticide management; critical areas protection; crop residue management; chisel tillage; pasture management; contour plowing; and livestock waste control. These minimum practices frequently were estimated to achieve a significant level of nonpoint source control.

Additional nonpoint pollution control practices were considered in the development and analysis of alternatives when further reductions were needed. In urban areas, these additional practices include increased street sweeping; improved street maintenance and refuse collection and disposal; increased leaf and debris collection; increased catch basin cleaning; stream bank protection; and vegetative buffer strips along streams and shorelines. Where a very high level of control is needed, storm water storage and treatment facilities were considered. In rural areas, additional practices considered include crop rotation; contour stripcropping; grassed waterways; diversions; wind erosion control; gradient terraces; stream bank protection; vegetative buffer strips along streams and shorelines; and, in cases where a very high level of control is needed, base-of-slope detention-storage facilities and construction of bench terraces. The foregoing practices were considered in alternatives analyses and for costing purposes during the planning program. The use of other practices which may be identified as practical and cost-effective in local planning and plan implementation is, of course, not precluded.

An empirical method developed by the Commission to systematically analyze the pollution potential of subbasins based on natural and cultural features was applied to develop a relative nonpoint source pollution potential rating for each subbasin within each watershed. This rating may be used in determining priorities for the design and implementation of nonpoint source control measures in the watershed.

The development of recommendations for point and nonpoint source control measures required the identification of the sources of pollution that were estimated to be resulting in violations of water quality standards. It was initially anticipated that plan alternatives would include point intensive and nonpoint intensive control sets. In general, it was found that nonpoint source controls were not substitutable for point source controls in this regard. Point sources were usually found to be the primary cause of phosphate-phosphorus and un-ionized ammonia-nitrogen violations, while fecal coliform violations were usually caused by nonpoint sources. Dissolved oxygen problems within the Region were usually caused by high oxygen demand from bottom deposits and benthic organisms. These bottom deposits are attributable to excessive historical and existing point source discharges, flow relief devices, and nonpoint source loadings. These dissolved oxygen problems in most cases are expected to be abated by the implementation of the recommended point source controls and minimum nonpoint source controls. Additional point source controls beyond those proposed in SEWRPC Planning Report No. 16 were relatively ineffective in ameliorating fecal coliform problems under the plan year 2000 land use conditions. On the other hand, nonpoint source controls were not estimated to be highly effective for controlling instream phosphate-phosphorus or un-ionized ammonia-nitrogen levels, especially in rural areas. Hence, an alternative allowing for a trade-off of additional point source controls for nonpoint source controls would seldom be feasible.

The basic analytic tool used to evaluate alternative plans was the hydrologic-hydraulic water quality simulation model. The procedure used to develop the alternative water quality management plans was to first identify the factors affecting water quality in each stream reach and lake studied—factors which included lake and stream bottom and flow conditions as well as existing and anticipated future sources of pollution. These factors were then analyzed and evaluated to identify potential approaches to required water pollution abatement. The determination of the most practical combination of point and nonpoint pollution control measures required was largely an iterative, "cut and try" process which began with an evaluation of the point source controls recommended in the regional sanitary sewerage system plan, followed by an assessment of the need for additional point or nonpoint source pollution controls as necessary to meet the applicable water use objectives. This iterative process, therefore, involved a series of successive attempts to design a plan that would meet the established water use objectives. Cost, technical and economic feasibility, likely environmental impact, and the extent to which water use objectives would be achieved were all considered in this alternative analysis process.

The analysis indicated that if the proposed combination of point and nonpoint source pollution control measures were fully implemented, about 1,054 stream miles, or 89 percent of the 1,180-stream mile network studied, and 94 of the 100 major lakes could be expected to meet the national goal of "fishable and swimmable" waters in the year 2000. The remaining 126 miles of stream, or 11 percent, could not as a practical matter achieve the standards that relate to the national goal of "fishable and swimmable" waters. These 126 stream miles are located in the Root, Menomonee, Milwaukee, and Kinnickinnic River watersheds where, in many cases, the stream channels have been extensively modified through concrete lining for flood management purposes. Of the 100 major lakes in the Region, only six may be expected not to meet the national goal of "fishable and swimmable" waters, because of the impracticality of reducing phosphorus levels to the required standard.

## Chapter V

## SUMMARY AND CONCLUSIONS

### INTRODUCTION

The major findings and recommendations of the regional water quality management planning program for southeastern Wisconsin conducted pursuant to Section 208 of the Federal Water Pollution Control Act are presented in two Commission planning reports. The first report, SEWRPC Planning Report No. 29, A Regional Wastewater Sludge Management Plan for Southeastern Wisconsin, sets forth the findings and recommendations of the planning program relative to wastewater sludge management. The estimates of the sludge quantities to be managed were, for the purpose of this report, derived from a preliminary point source pollution abatement plan. The second report, SEWRPC Planning Report No. 30, A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, is a three-volume report which sets forth the findings and recommendations of the planning program with respect to the abatement of point and nonpoint (diffuse) sources of water pollution. In addition, SEWRPC Planning Report No. 30 summarizes the wastewater sludge management recommendations set forth in SEWRPC Planning Report No. 29, adjusting such recommendations as necessary to reflect the more refined estimates of sludge quantities derived from the final point source element recommendations set forth in this report. The first volume of SEWRPC Planning Report No. 30, Inventory Findings, sets forth the basic principles and concepts underlying the water quality management study; discusses the relationship of the areawide water quality management planning program to the Commission's comprehensive regional planning program for southeastern Wisconsin; describes the existing natural and man-made features of the Region which affect and are affected by water quality; describes the existing level of water quality in the lakes and streams of the Region; describes the existing sources of water pollution in the Region; and describes the legal and financial structures which are available to support the implementation of recommended water quality management measures.

This, the second volume of SEWRPC Planning Report No. 30, Alternative Plans, sets forth recommended water quality management objectives, principles, and standards, including specific water use objectives, for the lakes and streams of the Region; discusses probable future growth and change in the population and economic activity levels and in the land use within the Region; compares the existing and forecast year 2000 water quality conditions with the recommended water use objectives and supporting water quality standards; and presents and evaluates alternative plans to meet the recommended water use objectives.

The third and final volume of SEWRPC Planning Report No. 30, Recommended Plan, presents the recommended regional water quality management plan, consisting of a land use element, a point source pollution abatement element, a nonpoint source pollution abatement element, a water quality monitoring element, and a residual wastewater sludge management element, the latter a refinement of the plan presented in SEWRPC Planning Report No. 29. In addition, the third volume presents recommendations concerning the means for achieving a staged implementation of the plan over the plan design period, including the identification of water quality management agencies. An environmental assessment of the recommended plan is included in an appendix of the third volume.

### OBJECTIVES, PRINCIPLES, AND STANDARDS

Planning is a rational process for formulating and meeting objectives. The objectives chosen guide the preparation of alternative plans and, when converted to standards, provide the criteria for evaluating the alternatives and selecting a recommended plan from among those alternatives. In the formulation of objectives, the regional water quality management planning program for southeastern Wisconsin built upon the previous planning work accomplished by the Commission by incorporating, amending, and extending as necessary the development objectives, principles, and standards formulated under the regional land use planning program, the regional sanitary sewerage system planning program, and the five subregional watershed planning programs completed to date. In this respect the program also built upon the natural water use objectives set forth in the Federal Water Pollution Control Act, as last amended in 1977. Through the use of technical and citizen advisory committees, public informational meetings, and public hearings, the Commission has attempted to actively involve elected officials and concerned citizens in the formulation of the regional water use and related development objectives, principles, and standards. Under the regional water quality management planning program, the preliminary recommended water use objectives and supporting water quality standards were widely disseminated in the September 1977 edition of Update, a water quality-related fact sheet distributed to about 3,500 citizens, elected officials, and interested organizations throughout the Region. In addition, reaction to the preliminary recommended objectives and standards was sought from the Citizens Advisory Panel for Public Participation on March 2, 1978. The public participation activity supplemented the normal Commission citizen participation activity obtained through its advisory committee structure and through public informational meetings and public hearings.

Seven specific regional land use development objectives previously formulated were reaffirmed as development objectives under the water quality management planning program, as were two water control facility development objectives formulated under the comprehensive watershed planning programs. The four development objectives formulated under the regional sanitary sewerage system planning program were expanded and reaffirmed. One new objective was formulated under the regional water quality management planning program, that relating to the development of water quality management institutions and supporting revenue-raising mechanisms. In addition, six specific regional wastewater sludge management objectives were formulated as documented in SEWRPC Planning Report No. 29. Accompanying each of the 20 development objectives is a planning principle and a set of planning standards that were used as a guide in the preparation and evaluation of the alternative plans.

One of the water quality management objectives concerns achieving the water quality goals advanced by the U. S. Congress in Public Law 92-500 and implemented in Wisconsin by the State Natural Resources Board through rules set forth in Chapters 102 through 105 of the Wisconsin Administrative Code. In Public Law 92-500, the Congress set as a national goal wherever attainable water quality which permits the protection and propagation of fish, shellfish, and wildlife, and which permits recreation in and on the water. This national goal of "fishable and swimmable" surface waters is to be achieved by 1983. The Congress and the U. S. Environmental Protection Agency have recognized that, as a practical matter, more limited use objectives may have to be established for some streams and lakes after consideration by the states of the social and economic costs of achieving the full objectives and the practical potential of streams and lakes for public water supply, propagation of fish and wildlife, recreation, agriculture, industry, and navigation.

In conducting the regional water quality management planning program for southeastern Wisconsin, an attempt was made to assign to all surface waters in the Region, in a manner discussed in more detail below, an appropriate combination of specific water use objectives formulated under the program that would meet the national goal of "fishable and swimmable" waters. At the present time, the water use objectives assigned by the Wisconsin Department of Natural Resources to many miles of surface streams in southeastern Wisconsin are based upon more limited use objectives than the national goal of "fishable and swimmable" waters. An analysis was made of the potential of each stream reach and of each major lake to meet objectives consistent with the national goal. This analysis took into account the results of inventories of stream and lake physical characteristics and conditions, existing water quality, sources of pollution in tributary drainage areas, the character of both existing and planned land uses in tributary drainage areas, and the location and extent of in-place pollutants. One of the planning tools used in the analysis was a hydrologic-hydraulic water quality simulation model, which served to synthesize much of the inventory and forecast data. This analysis, which is discussed in Chapter IV of this volume, and which was applied to a total of 1,180 stream miles and to 42 flow-through lakes and 30 headwater lakes together with a supplemental phosphorus loading analysis conducted for all 100 major lakes in the Region, indicated that for reasons relating to natural conditions, to gross levels of in-place pollutants, or to essentially irreversible man-made improvements, such as concrete channelization, it would not be practicable to meet the national goal of "fishable and swimmable" waters for all surface waters in the Region. However, these analyses also indicated that it would be possible to significantly raise the currently adopted water use objectives so that many more miles of streams could meet the national goal, or could meet a lower water use objective that nevertheless exceeds the minimum standards.

The following five combinations of water use objectives were recognized in the study and recommended to be applied to the 1,180-stream mile network and the 100 major lakes in the Region as shown on Map 1, in Chapter II of this volume:

1. Salmon spawning fishery and aquatic life, recreational use, and minimum standards.

2. Trout fishery and aquatic life, recreational use, and minimum standards.

3. Warmwater fishery and aquatic life, recreational use, and minimum standards.

4. Warmwater fishery and aquatic life, limited recreational use, and minimum standards.

5. Limited fishery and aquatic life, limited recreational use, and minimum standards.

Of the five water use objective combinations, only the first three, providing for the maintenance of a full warmwater fishery and for full body contact recreational use, are fully compatible with the national goal of "fishable and swimmable" waters. Of the 1,180-stream miles analyzed in the program, 1,054 miles, or 89 percent, fall into one of these three categories, including 27 miles, or 2 percent, in the trout fishery and recreational use category, and 1,027 miles, or 87 percent, in the warmwater fishery and recreational use category. The salmon spawning fishery and recreational use category applies only to portions of the Lake Michigan estuaries of five streams, which are not included in the 1,180-stream mile network. The remaining 126-stream miles, or about 11 percent, would not meet the national goal of "fishable and swimmable" waters. These stream miles generally have excessive nutrient levels which cannot as a practical matter be sufficiently reduced, or lie within an intensely urbanized portion of the Region and are permanently altered through concrete channelization. Of these 126-stream miles, 56 miles, or 5 percent, have been placed within the warmwater fishery and limited recreational use category, and 70 miles, or 6 percent, have been placed in the limited fishery and limited recreational use category. Significantly, the restricted use category now applied by the Natural Resources Board to about 60 stream miles of the 1,180-stream mile network in the Region is not recommended to be applied within the Region in future years, since the analysis indicated that at least a limited fishery and partial body contact recreational use, including wading and boating, can be achieved for all streams in the Region. It should be noted in this respect that cost considerations were not a basis for the recommended lower objectives, such objectives being established on the basis of practical considerations alone, such as the permanent alteration of streambeds through concrete channelization.

Of the 100 major lakes in the Region, 95 lakes are recommended to be assigned water use objectives that are fully compatible with the national goal of "fishable and swimmable" waters. Of these 95 lakes, one—Lake Geneva in Walworth County—has been placed in the trout fishery and recreational use category, and 94 have been placed in the warmwater fishery and recreational use category. Of the remaining five major lakes in the Region, one—Mud Lake in Ozaukee County—is recommended to be placed in the limited fishery and aquatic life and limited recreational use category because of natural bog conditions which preclude most recreational uses and the maintenance of a warmwater fishery. The remaining four lakes have been placed in the warmwater fishery and limited recreational use category because of estimated excessive nutrient loadings to the lakes which cannot, as a practical matter, be sufficiently reduced, resulting in relatively high rates of lake fertilization and aquatic growth.

## ANTICIPATED GROWTH AND CHANGE

The regional water quality management plan is intended to ensure that the surface waters of the Region will meet the recommended water use objectives, not only under existing land use, channel, and other development conditions affecting water quality within the Region, but under probable future conditions, which may be quite different from prevailing conditions. Since the regional water quality management planning program was conducted within the broad context of other Commission planning programs, the probable future population and economic activity levels and distribution patterns, land use development patterns, and channel conditions were provided directly by other Commission-adopted regional or subregional plan elements, most importantly including the adopted regional land use plan and the series of adopted comprehensive watershed plans. In this way, the regional water quality management planning program was fully coordinated with all other areawide planning programs for southeastern Wisconsin, including programs for land use, transportation systems, sewerage systems, park and open space, and air quality management planning.

Commission design year 2000 population and economic activity level forecasts, as well as the Commission regional land use plan which seeks to accommodate the changes in population and employment levels indicated by these forecasts, are set forth in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin: 2000, Volume Two, Alternative and Recommended Plans. The expected changes in population and economic activity levels, and in land use development, within the Region by the year 2000 may be summarized as follows:

1. The population of the Region may be expected to increase by approximately 463,000 persons over the 1970 population level of about 1.76 million persons, an increase of about 26 percent. Thus, the resident population of the Region in the design year of the plan—2000—may be expected to approximate 2.2 million persons. At the county level, the population forecasts indicate continued high population growth rates in Ozaukee, Washington, and Waukesha Counties, with lower rates of population growth in Kenosha, Racine, and Walworth Counties. Milwaukee County, currently experiencing a decline in population, would, under the forecast, be expected to lose population until 1980, when its population would stabilize. After 1985 the population of Milwaukee County would, under the forecast, begin to again increase, nearly reaching the 1970 level by the year 2000.

2. Employment in the Region by the year 2000 is expected to reach about 1.0 million jobs, an increase of about 237,000 jobs, or about 30 percent, over the 1975 employment level of 779,000 jobs. It is envisioned that the number of jobs will increase in all seven counties, with the largest increases occurring in Milwaukee and Waukesha Counties. Milwaukee County's proportion of total regional employment, however, would continue to decline, reflecting continued decentralization of jobs within the Region.

3. The population density of the developed urban areas of the Region is expected to continue to decline. This density, which peaked in 1920 at an average level of about 11,300 persons per square mile of developed urban land, declined to about 8,500 persons per square mile in 1950, and to 5,800 persons per square mile in 1963. By 1970 urban land uses in the Region occupied a total of about 512 square miles, and the average population density of the developed urban area had declined to about 4,400 persons per square mile. If the trends in land use decentralization exhibited over the period from 1963 to 1970 continue, land devoted to urban use within the Region would increase to about 831 square miles, an increase of 319 square miles, or 62 percent. The average population density of the urban area could be expected to decline further to about 2,300 persons per square mile. In contrast, the adopted regional land use plan for 2000, as described in SEWRPC Planning Report No. 25

and incorporated by reference herein as the basis for the development of the areawide water quality management plan, proposes that only about 113 square miles of land be converted from rural to urban use to accommodate growth and change in the Region through the year 2000, that the diffusion of urban development throughout the Region be halted, and that the decline in population density be arrested and the overall density of the developed urban area of the Region be held at a level of about 3,500 persons per square mile.

The recommended design year 2000 land use plan seeks to modify current land use development trends and centralize land use development to the greatest degree practicable (see Map 2). The degree of centralization is indicated by the fact that, under the plan, over 60 percent of all new urban residential land and nearly 49 percent of the incremental resident population would be located within 20 miles of the Milwaukee central business district. New urban development would be encouraged to occur at densities consistent with the economical provision of public sanitary sewer, water supply, and mass transit facilities and services, and in areas covered by soils well suited to urban use, not subject to special hazards such as flooding, and into which urban facilities and services can be readily and economically and efficiently extended. The plan envisions that new urban development would occur in planned neighborhood development units, primarily at medium-density population levels; that is, about four dwelling units per net residential acre, or about 5,000 persons per gross square mile. The plan envisions that by the year 2000, about 92 percent of all urban land and about 93 percent of all the people in the Region would be served with public sanitary sewer service.

The design year 2000 regional land use plan proposes that all Commission-identified primary environmental corridors be protected and preserved in essential natural open use. Such corridors contain the most important elements of the natural resource base of the Region, including the best remaining woodlands, wetlands, wildlife habitat areas, surface waters and associated shorelands and floodlands, areas covered by organic soils, areas containing rough topography and significant geological formations, areas of scientific, historic, or cultural value, groundwater recharge and discharge areas, existing park sites, and park and related open space sites. These natural resource base elements occur largely together in linear patterns in the natural landscape, and thus comprise the environmental corridors. The primary environmental corridors encompass only about 20 percent, or 542 square miles, of the area of the Region, but their preservation in essentially natural open uses can do much to maintain the overall quality of the environment and to prevent the future creation of serious and costly developmental and environmental problems.

The year 2000 regional land use plan also proposes to preserve to the greatest extent practicable those areas identified as prime agricultural lands. In 1970 such lands totaled about 746 square miles, or 28 percent of the area of the Region. The year 2000 plan proposes to convert to urban use only those prime agricultural lands which have already been committed to urban development due to the proximity to existing and expanding concentrations of urban uses and the prior commitment of heavy capital investments in utility extensions. Only about 8,000 acres, or about 2 percent, of the prime agricultural lands would be converted to urban use under the plan. The preservation of these agricultural lands is considered important for environmental as well as economic reasons.

Projections were made in the regional water quality management planning program of the future levels of total public expenditures, and of the future levels of public expenditures for water quality-related projects. Total expenditures by local units of government are projected to increase from the 1975 level of about $1.12 billion to about $2.33 billion in the year 2000, an increase of about 108 percent measured in constant 1976 dollars. Over the same period, water quality-related expenditures are projected to increase from $116.2 million to about $247.0 million, an increase of about 112 percent, also measured in constant 1976 dollars.

## ALTERNATIVE PLANS

In the preparation of the regional water quality management plan, a concerted effort was made to offer for public evaluation a full range of physically feasible and practical alternative plans directed toward abating existing water pollution and achieving the recommended water use objectives. Each alternative plan element was evaluated for technical and economic feasibility, likely environmental impact, and financial and legal feasibility, as well as for the extent to which the water use objectives were satisfied. The basic analytical tool used to evaluate the alternative plans was the hydrologic-hydraulic water quality simulation model developed for use in the program. Alternatives were developed with respect to the abatement of pollution from point sources, defined to include public and private sewage treatment plants, sewerage system flow relief devices, and industrial waste discharges, including cooling, process, rinse, and wash water discharges. Similarly, alternatives were developed with respect to the abatement of pollution from nonpoint, or diffuse, sources, defined to include, in urban areas, runoff from residential, commercial, industrial, transportation, and recreational land uses, construction activities, and onsite sewage disposal systems; and in rural areas, runoff from cropland, pasture, and woodland land uses and livestock raising operations. Atmospheric contributions, while occurring in rural and urban areas, were arbitrarily classified as a rural source. Alternatives were developed not only for the management of stream water quality but for the management of the water quality of each of the 100 major lakes in the Region. Alternatives were also developed for wastewater sludge management; these have been documented separately in SEWRPC Planning Report No. 29.

Probabilistic Nature of Approach to Standards Application

In designing and testing alternative water pollution abatement plans, an approach to interpretation and application of the water quality standards that support the water use objectives set forth in Chapter II of this volume was required. The water quality simulation analysis indicated that achievement of the water quality standards on an absolute basis, that is, 100 percent of the time, was not feasible given the natural conditions in the Region and the known techniques for water pollution control. A review of the simulation results for those streams which exhibited a relatively low level of standards violation—about 5 to 10 percent—indicated that neither the duration nor the intensity of the violations was so severe as to affect the fisheries in any significant manner. Furthermore, a review and evaluation of the available water quality monitoring data for relatively clean or "unpolluted" streams in the Region, that is, those streams where the use objectives are now being met, indicated that even these streams do not satisfy the water quality standards all of the time. It was recognized, therefore, that exceeding the standards for relatively brief periods would not generally affect the intended use of the surface waters.

In the past, water quality has often been evaluated only during low flow periods when determining the specific effects of point sources of pollution on water quality. However, how often water quality standards are exceeded during periods of high flow, or during storm events after long intervening periods of dry weather and the associated buildup of pollutants on the land surface—conditions that produce high pollutant washoff from the land surface—cannot be determined by applying these standards only to streamflows equal to or less than some low flow condition. Generally, such relatively higher flow conditions were found to have a significant effect on the achievement of water use objectives. Moreover, previous Commission studies, documented in the adopted regional sanitary sewerage system plan, addressed the levels of control necessary for achievement of the standards as evaluated against low flow conditions. The resulting effluent quality recommendations were used as the point of departure for the alternatives evaluations documented in this volume.

Accordingly, in the regional water quality management planning program the assessment of water quality conditions against the physical and chemical criteria in the water quality standards was based upon the percent of time the water quality conditions were found to be in compliance with the specified limits. It was also recognized that point source pollution abatement measures should continue to be designed to meet the standards during the 7 day-10 year low flow conditions in the receiving water. Under the method applied, statistical analyses were prepared using the results of the continuous water quality simulation modeling to determine the percent of time a given standard may be expected to be violated under specified conditions. These analyses included periods of both high and low flow. As a practical matter, a 95 percent compliance level—meaning water quality standards shall be met 95 percent of the time—was selected as the criterion for those parameters which may have direct lethal effects on desirable forms of aquatic life—dissolved oxygen, temperature, un-ionized ammonia-nitrogen, and pH. A 90 percent compliance level was selected as the criterion for those parameters which do not have direct lethal effects on such aquatic organisms—phosphorus and fecal coliform. This probabilistic approach to application of the water quality standards formed the basis for evaluation of all of the alternative plans considered.

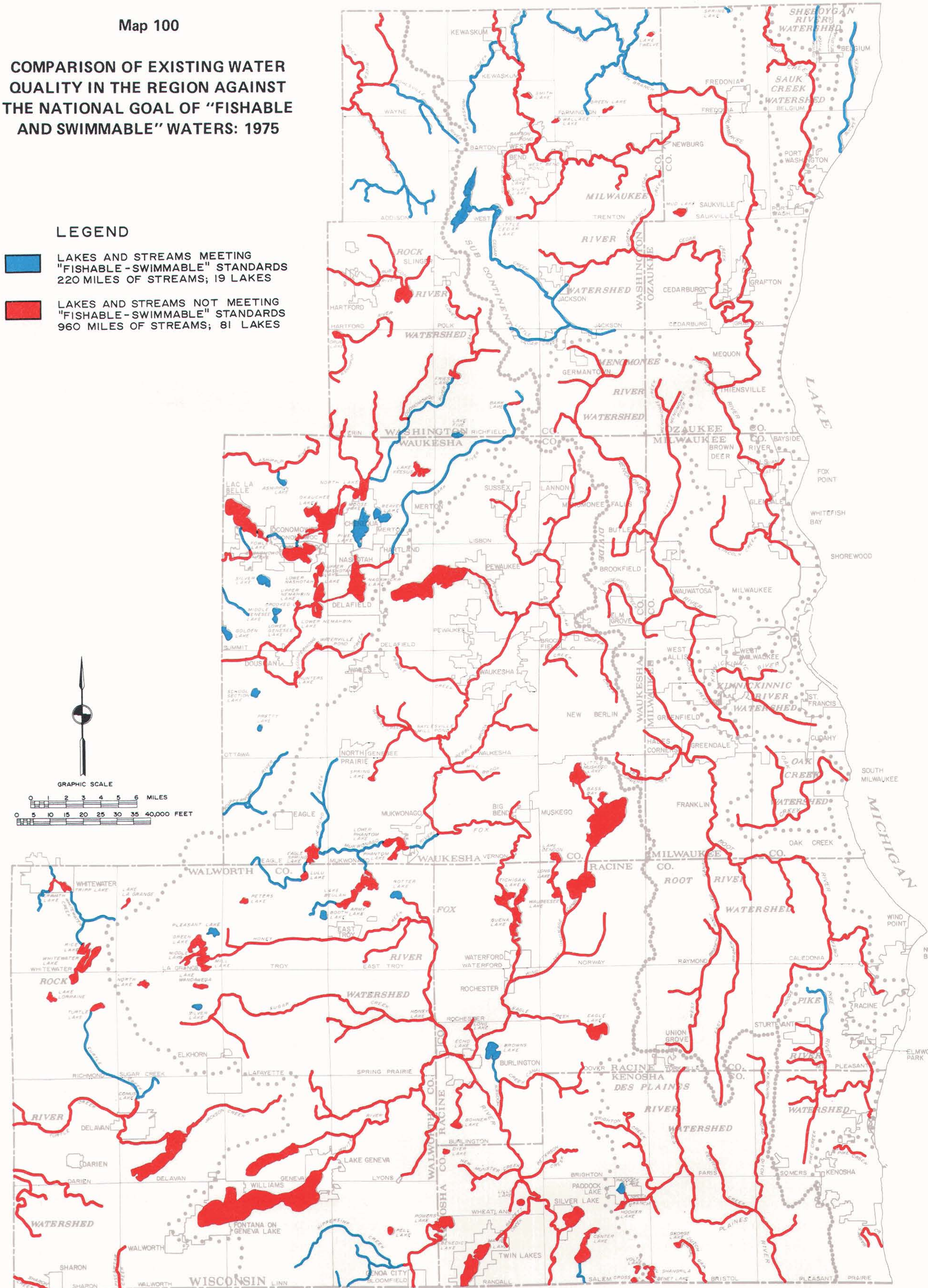
Determination of the Extent to Which the National Goal of "Fishable and Swimmable" Waters Can Be Met

As discussed in Chapter II of this volume, the currently adopted water use objectives and supporting water quality standards for Wisconsin as applied in the Southeastern Wisconsin Region were not fully consistent with the national goal of "fishable and swimmable" waters for all surface waters of the Region. Thus, the basic purpose of the regional water quality management planning program was to prepare a plan that would call for cost-effective actions to control pollution from both point and nonpoint sources so as to meet this national goal, or, if that was determined to be impractical, to meet some lesser goal as defined by the revision of water use objectives. The process of preparing the regional water quality management plan, then, was iterative in nature, involving a series of successive attempts to design a plan that would meet the national goal to the maximum extent practicable.

The plan design process began with a determination of the extent to which surface water quality in the Region in the base year 1975 met the national goal of "fishable and swimmable" waters. This step involved the application of the water quality simulation model developed for the study under existing conditions, the model being carefully calibrated using the water quality and pollution source inventory data developed in the study. This analysis was conducted with respect to a 1,180-stream mile network. In addition, a phosphorus loading analysis was conducted for each of the 100 major lakes in the Region. The results of these initial analyses are graphically summarized on Map 100. The initial simulation model analysis indicated that of the 1,180 stream miles analyzed, about 221 miles, or 19 percent, actually met the national goal of "fishable and swimmable" waters in 1975 (see Table 223). The remaining 960 miles, or 81 percent, exhibited violations of one or more supporting water quality standards in excess of the percent of time tolerances noted above. Of the 221 stream miles meeting the standard in 1975, 58 miles were located in the Fox River watershed, consisting primarily of all or portions of the Mukwonago River, Jericho Creek, Nippersink Creek, and Hoosier Creek; about 59 miles were located in the Milwaukee River watershed, consisting primarily of all or portions of the East Branch and North Branch of the Milwaukee River, Kewaskum Creek, and Cedar Creek; and 89 miles were located in the Rock River watershed, consisting primarily of all or portions of the Bark River, Turtle Creek, Kohlsville

Map 100

## COMPARISON OF EXISTING WATER QUALITY IN THE REGION AGAINST THE NATIONAL GOAL OF "FISHABLE AND SWIMMABLE" WATERS: 1975




Under existing conditions it was estimated that about 221 miles, or about 19 percent of the 1,180-stream mile network analyzed, actually met the national goal of "fishable and swimmable" waters in 1975. The remaining 960 miles exhibited violations of one or more of the supporting water quality standards for significant periods of time. The analyses also indicated that 19 of the 100 major lakes in the Region met the national water quality goal in 1975.

*Source: SEWRPC.*

## Table 223

### COMPARISON OF EXISTING AND FORECAST STREAM WATER QUALITY IN THE REGION AGAINST THE NATIONAL GOAL OF "FISHABLE AND SWIMMABLE" WATERS

| Watershed | Stream Miles Analyzed | Existing 1975 Conditions | | | | Forecast 2000 Conditions—"Do Nothing" Alternative | | | | Forecast 2000 Conditions—Point Source Controls as Recommended in Regional Sanitary Sewerage System Plan | | | | Forecast 2000 Conditions—Intensive Nonpoint Source Controls | | | | Forecast 2000 Conditions—Maximum Practical Point and Nonpoint Source Controls | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Standards Met | | Standards Not Met | | Standards Met | | Standards Not Met | | Standards Met | | Standards Not Met | | Standards Met | | Standards Not Met | | Standards Met | | Standards Not Met | |
| | | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total | Number of Miles | Percent of Watershed Total |
| Des Plaines River | 66.7 | - - | - - | 66.7 | 100.0 | - - | - - | 66.7 | 100.0 | - - | - - | 66.7 | 100.0 | 39.2 | 58.8 | 27.5 | 41.2 | 66.7 | 100.0 | - - | - - |
| Fox River | 399.4 | 58.0 | 14.4 | 341.4 | 85.6 | 58.0 | 14.5 | 341.4 | 85.5 | 58.0 | 14.5 | 341.4 | 85.5 | 252.3 | 63.2 | 147.1 | 36.8 | 399.4 | 100.0 | - - | - - |
| Kinnickinnic River | 11.8 | - - | - - | 11.8 | 100.0 | - - | - - | 11.8 | 100.0 | - - | - - | 11.8 | 100.0 | - - | - - | 11.8 | 100.0 | - - | - - | 11.8 | 100.0 |
| Menomonee River | 73.9 | - - | - - | 73.9 | 100.0 | - - | - - | 73.9 | 100.0 | - - | - - | 73.9 | 100.0 | - - | - - | 73.9 | 100.0 | - - | - - | 73.9 | 100.0 |
| Milwaukee River | 192.7 | 58.8 | 30.5 | 133.9 | 69.5 | 57.4 | 29.8 | 135.3 | 70.2 | 55.7 | 28.9 | 137.0 | 71.1 | 92.0 | 47.7 | 100.7 | 52.3 | 186.6 | 96.8 | 6.1 | 3.1 |
| Minor Streams Tributary to Lake Michigan | | | | | | | | | | | | | | | | | | | | | |
| Barnes Creek | 2.9 | - - | - - | 2.9 | 100.0 | - - | - - | 2.9 | 100.0 | - - | - - | 2.9 | 100.0 | 2.9 | 100.0 | - - | - - | 2.9 | 100.0 | - - | - - |
| Pike Creek | 1.7 | - - | - - | 1.7 | 100.0 | - - | - - | 1.7 | 100.0 | - - | - - | 1.7 | 100.0 | 1.7 | 100.0 | - - | - - | 1.7 | 100.0 | - - | - - |
| Sucker Creek | 9.2 | 9.2 | 100.0 | - - | - - | 9.2 | 100.0 | - - | - - | 9.2 | 100.0 | - - | - - | 9.2 | 100.0 | - - | - - | 9.2 | 100.0 | - - | - - |
| Oak Creek | 18.4 | - - | - - | 18.4 | 100.0 | - - | - - | 18.4 | 100.0 | - - | - - | 18.4 | 100.0 | 18.4 | 100.0 | - - | - - | 18.4 | 100.0 | - - | - - |
| Pike River | 33.7 | 3.3 | 10.0 | 30.4 | 90.0 | 5.7 | 16.9 | 28.0 | 83.1 | 5.7 | 16.9 | 28.0 | 83.1 | 33.7 | 100.0 | - - | - - | 33.7 | 100.0 | - - | - - |
| Rock River | 255.1 | 88.6 | 34.7 | 166.5 | 65.3 | 108.2 | 42.4 | 146.9 | 57.6 | 108.2 | 42.4 | 146.9 | 57.6 | 218.1 | 85.5 | 37.0 | 14.5 | 255.1 | 100.0 | - - | - - |
| Root River | 96.8 | - - | - - | 96.8 | 100.0 | - - | - - | 96.8 | 100.0 | - - | - - | 96.8 | 100.0 | 17.5 | 17.7 | 79.3 | 82.3 | 62.2 | 64.3 | 34.6 | 35.7 |
| Sauk Creek | 15.5 | - - | - - | 15.5 | 100.0 | - - | - - | 15.5 | 100.0 | - - | - - | 15.5 | 100.0 | 15.5 | 100.0 | - - | - - | 15.5 | 100.0 | - - | - - |
| Sheboygan River | 2.6 | 2.6 | 100.0 | - - | - - | 2.6 | 100.0 | - - | - - | 2.6 | 100.0 | - - | - - | - - | - - | 2.6 | 100.0 | 2.6 | 100.0 | - - | - - |
| Total | 1,180.4 | 220.5 | 18.7 | 959.9 | 81.3 | 241.1 | 20.4 | 939.3 | 79.6 | 239.4 | 20.3 | 941.0 | 79.7 | 700.5 | 59.3 | 479.9 | 40.7 | 1,054.0 | 89.3 | 126.4 | 10.7 |

*Source: SEWRPC.*

River, Limestone Creek, Oconomowoc River, Scuppernong Creek, Whitewater Creek, and several other minor streams. The remaining stream mileage meeting the national goal in 1975 was scattered throughout the Sheboygan River, Pike River, and Sucker Creek watersheds. The analysis also indicated that a total of 19 of the 100 major lakes in the Region met the national water quality goal in 1975 (see Map 100 and Table 224).

The next step in the evaluation involved the determination of the extent to which the national goal of "fishable and swimmable" waters could be met in the design year 2000, given future land use development in substantial conformance with the adopted regional land use plan, and given no significant change in current practices to control water pollution. In essence, this analysis amounted to an examination of a "do nothing" alternative with respect to water pollution control efforts over and above what is currently being accomplished. The only exceptions to the "do nothing" posture were major trunk sewer and sewage treatment plant projects that were considered to be fully committed. These projects included the construction of trunk sewers for Hales Corners and Menomonee Falls by the Milwaukee Metropolitan Sewerage District which would permit the abandonment of the Hales Corners and Menomonee Falls sewage treatment plants; the construction of the new sanitary sewerage system serving the Town of Norway Sanitary District No. 1 and the Denoon Lake area in the City of Muskego; the construction of the Town of

## Table 224

### COMPARISON OF EXISTING AND FORECAST LAKE WATER QUALITY IN THE REGION AGAINST THE NATIONAL GOAL OF "FISHABLE AND SWIMMABLE" WATERS

| Watershed | Number of Major Lakes | Existing 1975 Conditions | | Forecast 2000 Conditions—"Do Nothing" Alternative | | Forecast 2000 Conditions—Point Source Controls as Recommended in Regional Sanitary Sewerage System Plan | | Forecast 2000 Conditions—Intensive Nonpoint Source Controls | | Forecast 2000 Conditions—Maximum Practical Point and Nonpoint Source Controls | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Number of Lakes Meeting Standards | Number of Lakes Not Meeting Standards | Number of Lakes Meeting Standards | Number of Lakes Not Meeting Standards | Number of Lakes Meeting Standards | Number of Lakes Not Meeting Standards | Number of Lakes Meeting Standards | Number of Lakes Not Meeting Standards | Number of Lakes Meeting Standards | Number of Lakes Not Meeting Standards |
| Des Plaines River | 4 | 1 | 3 | 1 | 3 | 2 | 2 | 4 | - - | 4 | - - |
| Fox River | 46 | 5 | 41 | 4 | 42 | 5 | 41 | 41 | 5 | 43 | 3 |
| Milwaukee River | 12 | 3 | 9 | 3 | 9 | 3 | 9 | 9 | 3 | 11 | 1 |
| Rock River | 38 | 10 | 28 | 6 | 32 | 8 | 30 | 37 | 1 | 37 | 1 |
| Total | 100 | 19 | 81 | 14 | 86 | 18 | 82 | 91 | 9 | 95 | 5 |

*Source: SEWRPC.*

Dover-Eagle Lake sanitary sewerage system; the construction of a new sewage treatment facility to serve the Village of Union Grove; the construction of the Sturtevant-Mt. Pleasant trunk sewer, which would permit the abandonment of the Sturtevant sewage treatment plant; the completion of an expansion program at the City of Racine sewage treatment facility to permit full secondary treatment; the construction of a new sewage treatment facility to serve the City of West Bend; the construction of a new sewage treatment facility to serve the City of Oconomowoc; the construction of a new sewage treatment facility to serve the City of Waukesha; the construction of a new Delafield-Hartland sanitary sewerage system, including the abandonment of the existing Hartland sewage treatment facility; and the construction of the Pewaukee-Brookfield trunk sewer, permitting abandonment of the Pewaukee sewage treatment facility and the provision of centralized sanitary sewer service to the Pewaukee Lake Sanitary District. All of these actions were considered to be fully committed water pollution control facility improvements.

The results of this analysis are summarized in Tables 223 and 224 and on Map 101. This analysis indicated that about 241 miles, or about 20 percent of the 1,180 stream mile network in the Region, could be expected to meet the national goal of "fishable and swimmable" waters by the year 2000 under the specified conditions. Similarly, as shown in Table 224, it is estimated that only 14 of the 100 major lakes in the Region would meet the national water quality goal by the year 2000. These changes from the existing 1975 conditions can be largely attributed to the implementation of the point source pollution abatement projects listed above and to increased nonpoint source pollutant loads to lakes.

An analysis was then conducted of the extent to which the national goal of "fishable and swimmable" waters could be met in the Region by the year 2000 if it were assumed that all of the point source pollution abatement control recommendations set forth in the adopted regional sanitary sewerage system plan would be implemented. This analysis was conducted to determine the extent to which the national water quality goal could be met if only the previously recommended point source pollution abatement plan would be implemented utilizing conventional treatment technology. The results of this analysis are graphically summarized on Map 102 and are quantitatively presented in Tables 223 and 224. About 239 stream miles, or about 20 percent of the 1,180 stream mile network analyzed in the study, could be expected to meet the national water quality goal in the year 2000 if the point source pollution abatement recommendations contained in the regional sanitary sewerage system plan were fully carried out. Similarly, 18 of the 100 major lakes in the Region could be expected to meet the national goal.

These estimates are similar to those obtained in the "do nothing" alternative analysis, which is to be expected given the fact that many of the important recommendations contained in the regional sanitary sewerage system plan have already been implemented or were considered to be fully committed under the "do nothing" alternative. A net decrease in the number of stream miles expected to meet national water quality goals of 1.7 miles is attributable to the phosphorus load contributed to the North Branch of the Milwaukee River by the proposed Forest Lake and Kettle Moraine sewage treatment plants. In addition, it is important to note that implementation of the previously recommended point source pollution abatement measures would greatly contribute to improved water quality over the "do nothing" alternative, even though the national goal as defined by the use objectives and supporting standards would not be fully met. The national goal would not be fully achieved because of violations of the fecal coliform standards throughout much of the Region due to pollution from nonpoint sources, violations of phosphorus standards due to combinations of nonpoint sources and point sources, and violations of dissolved oxygen standards due principally to algae and to sediment oxygen demand from historic point source loadings and nonpoint source loads. Although violations occur as a result of the combined effects of point and nonpoint loads, it was further noted that even the provision of higher levels of advanced waste treatment of the point sources in the Region would not result in the achievement of the standards for fecal coliform and, in some cases, dissolved oxygen and phosphorus in many stream reaches. Therefore, one of the major conclusions of the regional water quality management planning program for southeastern Wisconsin is that the national goal of "fishable and swimmable" waters cannot be met through an intensive point source pollution abatement control effort alone. Nonpoint pollution control efforts will also be required.

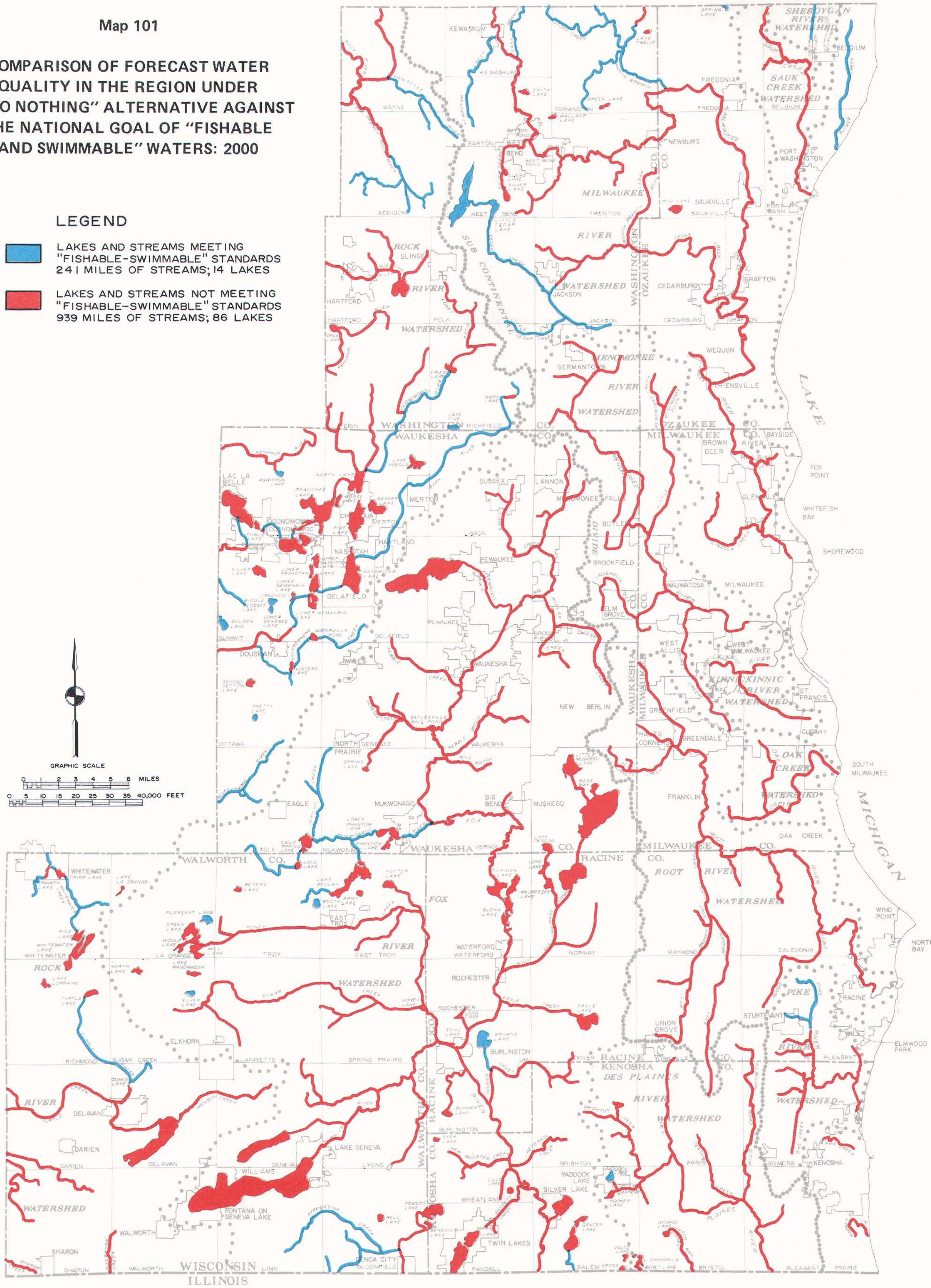
The next step in the analysis was to determine the extent to which the national goal of "fishable and swimmable" waters would be met in the Region by the year 2000 if only intensive nonpoint pollution controls were implemented and no additional effort were made to improve point source pollution other than that assumed in the "do nothing" alternative described above. The results of this analysis are summarized on Map 103 and in Tables 223 and 224. Significantly, about 701 stream miles, or 59 percent of the 1,180-stream mile network analyzed, could be expected to meet the national water quality goal by the year 2000 given an intensive nonpoint source control effort. Similarly, 91 of the 100 major lakes in the Region could be expected to meet the national water quality goal. An examination of Map 103 reveals that those stream reaches *not* meeting the national water quality goal under this alternative involved either those flowing through heavily urbanized areas or those lying directly below sewage treatment plant outfalls. Generally, the water quality standard violations involved excessive levels of phosphorus in both instances. Another major conclusion of the study, therefore, was that the national goal of "fishable and swimmable" waters could not be met in the Region through an intensive nonpoint source pollution control effort alone. Rather, some appropriate

Map 101

## COMPARISON OF FORECAST WATER QUALITY IN THE REGION UNDER A "DO NOTHING" ALTERNATIVE AGAINST THE NATIONAL GOAL OF "FISHABLE AND SWIMMABLE" WATERS: 2000

LEGEND

- LAKES AND STREAMS MEETING "FISHABLE-SWIMMABLE" STANDARDS 241 MILES OF STREAMS; 14 LAKES
- LAKES AND STREAMS NOT MEETING "FISHABLE-SWIMMABLE" STANDARDS 939 MILES OF STREAMS; 86 LAKES

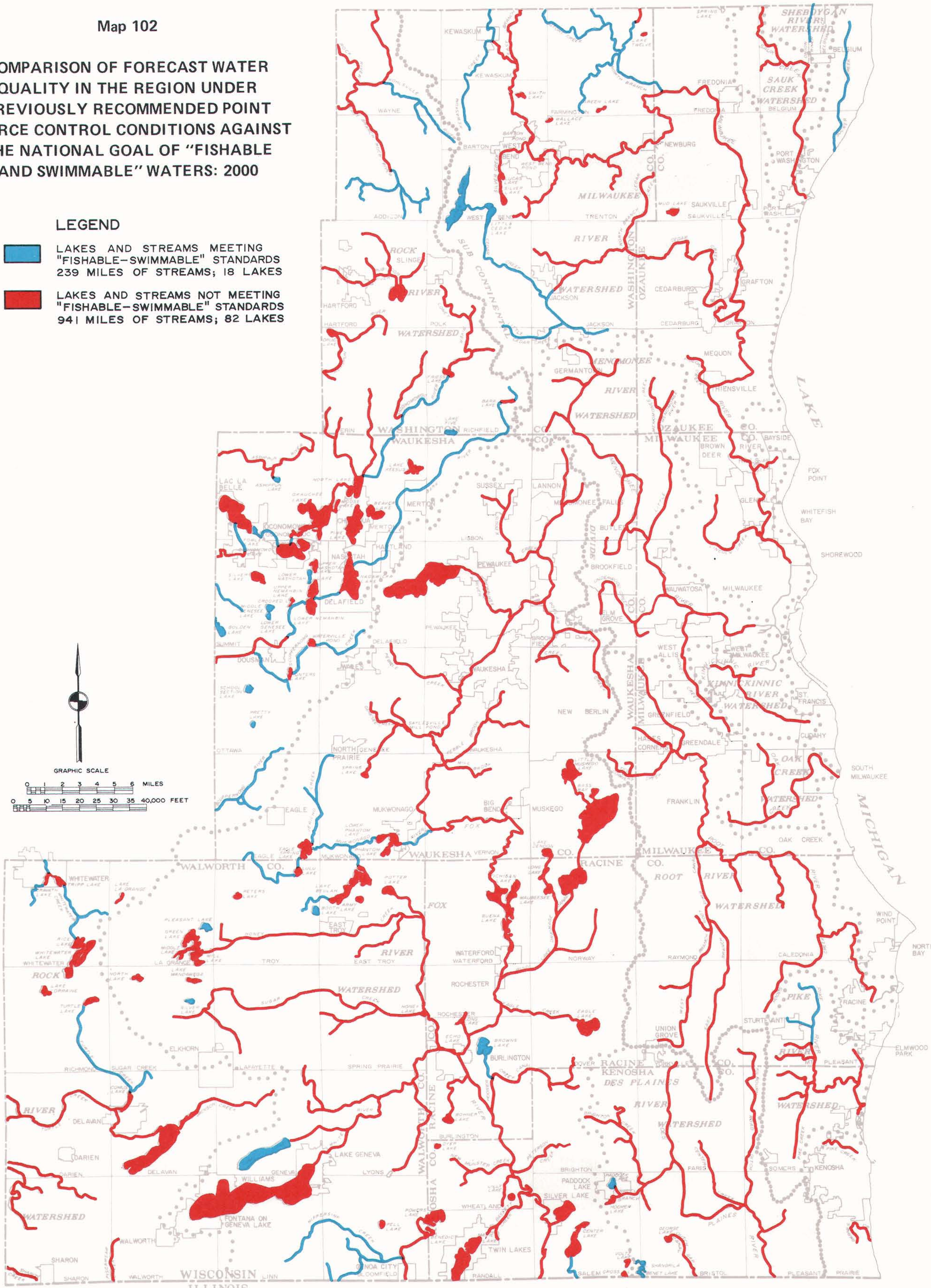



Analyses were conducted to estimate the probable future water quality conditions in the Region under a "do nothing" alternative. These analyses assumed future land use development in conformance with the adopted regional land use plan, but no substantial changes in current practices for water pollution control. The "do nothing" alternative assumed the construction of major trunk sewer and sewage treatment plant projects which were fully committed to completion as of 1978. Under this alternative, the analysis indicated that about 241 miles, or about 20 percent of the 1,180 stream miles analyzed, could be expected to meet the national goal of "fishable and swimmable" water quality by the year 2000. Similarly, it was estimated that only 14 of the major 100 lakes in the Region could be expected to meet the national water quality goal by the year 2000.

*Source: SEWRPC.*

Map 102

## COMPARISON OF FORECAST WATER QUALITY IN THE REGION UNDER PREVIOUSLY RECOMMENDED POINT SOURCE CONTROL CONDITIONS AGAINST THE NATIONAL GOAL OF "FISHABLE AND SWIMMABLE" WATERS: 2000

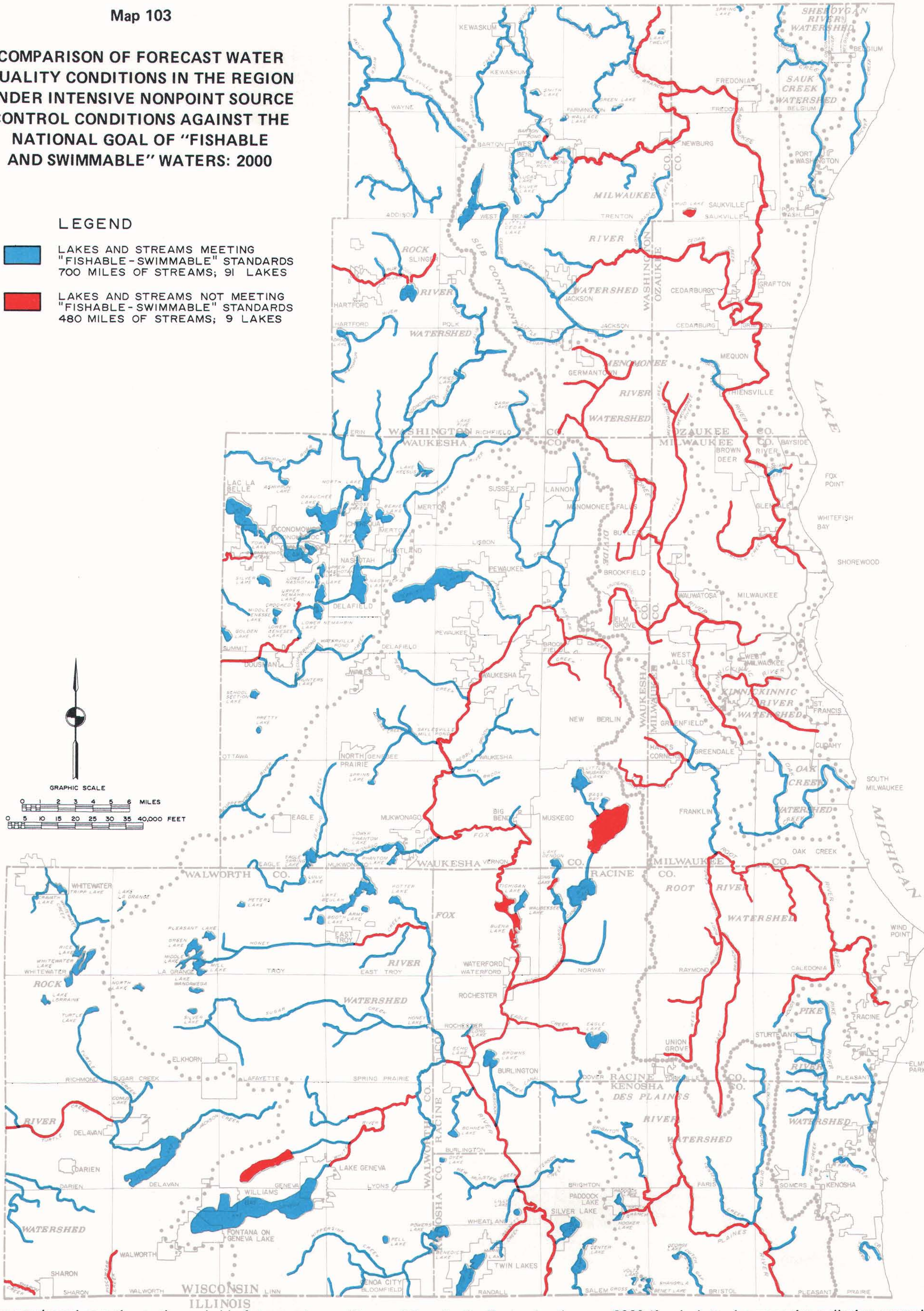



Analyses were conducted to estimate probable future water quality conditions in the Region assuming that all of the point source pollution abatement control recommendations set forth in the adopted regional sanitary sewerage system plan were implemented. This alternative assumed land use development in conformance with the adopted land use plan, but included no additional nonpoint source controls. Under this alternative, it is estimated that about 239 stream miles, or about 20 percent of the 1,180-stream mile network analyzed, could be expected to meet the national goal of "fishable and swimmable" water quality by the year 2000. Similarly, it is estimated that only 18 of the 100 major lakes in the Region could be expected to meet the national water quality goal by the year 2000.

*Source: SEWRPC.*

## Map 103

### COMPARISON OF FORECAST WATER QUALITY CONDITIONS IN THE REGION UNDER INTENSIVE NONPOINT SOURCE CONTROL CONDITIONS AGAINST THE NATIONAL GOAL OF "FISHABLE AND SWIMMABLE" WATERS: 2000




Analyses were conducted to estimate the probable future water quality conditions in the Region by the year 2000 if only intensive nonpoint pollution controls were implemented and no additional effort were made to improve point source pollution controls. Significantly, 701 stream miles, or 59 percent of the 1,180-stream mile network analyzed, could be expected to meet the national goal of "fishable and swimmable" water quality by the year 2000 under this intensive nonpoint source control condition. Similarly, it was estimated that 91 of the 100 major lakes in the Region could be expected to meet the national water quality goal by the year 2000.

*Source: SEWRPC.*

combination of intensive point and intensive nonpoint source pollution control measures must be identified if the national goal of "fishable and swimmable" waters is to be met.

The last step in the analysis involved the determination of the appropriate combination of both point and nonpoint source pollution control measures required. Chapter IV of this volume contains an extensive discussion of all of the alternative measures considered, the process consisting largely of an iterative "cut and try" method of plan design. The end result of the plan design process in terms of the national water quality goals is summarized on Map 104 and in Tables 223 and 224. The analysis indicated that if the recommended combination of point and nonpoint source pollution control measures that were derived from the analysis of all available alternatives were to be carried out and fully implemented, about 1,054 stream miles, or 89 percent of the 1,180-stream mile network studied, would meet the national goal of "fishable and swimmable" waters in the year 2000. The remaining 126 miles, or 11 percent, could not as a practical matter achieve the standards required to meet the national goal of "fishable and swimmable" waters. These 126 stream miles are located in the Root, Menomonee, Milwaukee, and Kinnickinnic River watersheds where, in many cases, the stream channels have been extensively changed through concrete lining to effect storm water management, or where there exist gross levels of natural or man-made pollutants which cannot as a practical matter be reduced. Of the 100 major lakes in the Region, only five may be expected not to meet the national goal of "fishable and swimmable" waters, because of the impracticality of reducing phosphorus levels to the required standard.

Before recommendations could be made for point and nonpoint source control measures, a determination of what sources of pollution were resulting in the violation of water quality standards was required. In general, it was found that nonpoint source controls could not be substituted for point source controls. Point sources were usually found to be the primary cause of phosphorus and ammonia-nitrogen violations, although nonpoint source controls were also required to achieve the standards for these parameters in some cases. Fecal coliform violations were usually caused by nonpoint sources. Dissolved oxygen problems within the Region were usually caused by high oxygen demand from bottom deposits and benthic organisms. These bottom deposits are attributable to excessive historical and existing point source discharges, flow relief devices, and nonpoint source loadings. In most cases, these dissolved oxygen problems are expected to be abated by the implementation of the recommended point source controls and minimum nonpoint source controls. Additional point source controls beyond those proposed in the regional sanitary sewerage system plan were found to be relatively ineffective in reducing fecal coliform problems under year 2000 land use conditions, and nonpoint source controls were not generally found to be effective abatement measures for controlling instream phosphate-phosphorus or un-ionized ammonia-nitrogen levels, expecially in rural areas. Therefore, additional point source controls could seldom be substituted for nonpoint source controls. In cases where such substitutions were found possible, the least costly pollution abatement measure was recommended.

Nature of Alternatives for Point Source Pollution Control

Prior to the initiation of the regional water quality management planning effort, the Commission had completed and adopted a series of comprehensive watershed plans and a regional sanitary sewerage system plan. These plans set forth a series of recommendations for the abatement of pollution from all of the major point sources of pollution within the Region, including separate and combined sewer overflows and sewage treatment plant outfalls. The regional sanitary sewerage system plan, which incorporated previous watershed plan recommendations, was used as a point of departure in the development of alternative plans for point source pollution control. Many of the decisions made in the regional sanitary sewerage system plan had become committed at the onset of the regional water quality management planning effort. These commitments ranged from the initiation of Section 201 sewerage facilities planning efforts to refine and detail the regional sanitary sewerage system plan recommendations to the actual construction of facilities. Consequently, these committed decisions were not reconsidered in the regional water quality management planning program. The point source pollution abatement planning effort in the regional water quality management planning program thus consisted of making refinements to the previously adopted plan. Such refinements involved, in a relatively few cases, an examination of sewage treatment plant interconnection alternatives that had been previously screened as not being cost-effective given the then-postulated water use objectives and attendant higher levels of treatment required. These alternatives are described and discussed in Chapter IV of this volume. In other cases, the original plan was refined by reconsidering land application of sewage effluent, particularly with respect to the smaller sewage treatment facilities located in the more rural portions of the Region. Reconsideration of this method of wastewater treatment and disposal was found to be desirable because of the advances in the state-of-the-art since completion of the regional sanitary sewerage system plan, and because higher levels of wastewater treatment were found to be needed in some cases to meet the recommended water use objectives and supporting standards, thus making the land application alternative economically more attractive. Other minor refinements included adjustments to the location and sizing of intercommunity trunk sewers to reflect the revised population forecast and the accompanying new regional land use plan.

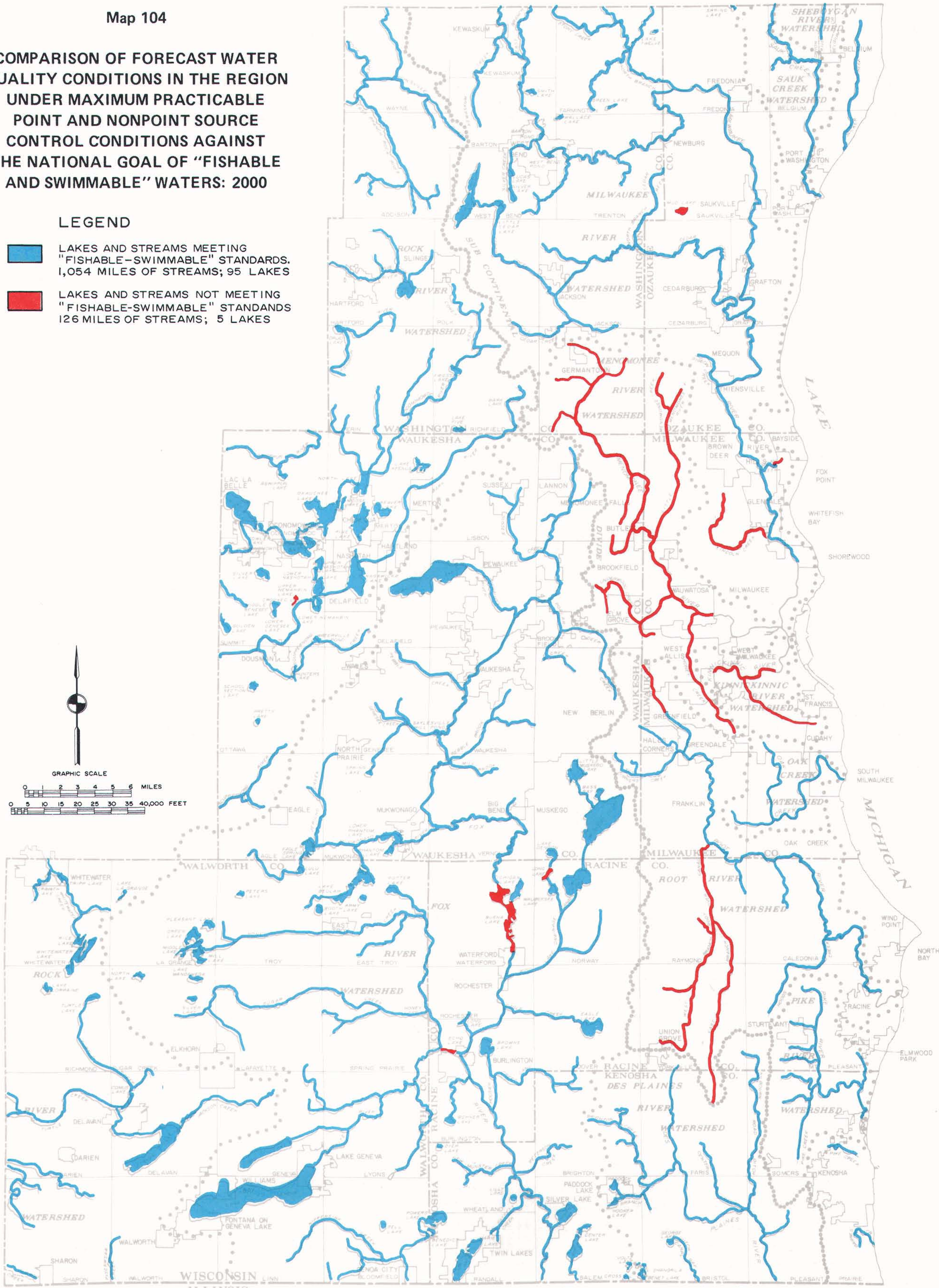
The regional water quality management planning program incorporated the trunk sewer proposals set forth in the adopted regional sanitary sewerage system plan. In this respect, it should be noted that a major Section 201 sewerage facilities planning program for the Milwaukee Metropolitan Sewerage District was begun as the Section 208 water quality management planning effort was

Map 104

## COMPARISON OF FORECAST WATER QUALITY CONDITIONS IN THE REGION UNDER MAXIMUM PRACTICABLE POINT AND NONPOINT SOURCE CONTROL CONDITIONS AGAINST THE NATIONAL GOAL OF "FISHABLE AND SWIMMABLE" WATERS: 2000

LEGEND

- LAKES AND STREAMS MEETING "FISHABLE–SWIMMABLE" STANDARDS. 1,054 MILES OF STREAMS; 95 LAKES
- LAKES AND STREAMS NOT MEETING "FISHABLE–SWIMMABLE" STANDANDS 126 MILES OF STREAMS; 5 LAKES




Analyses were conducted to estimate the probable future water quality conditions in the Region by the year 2000 if a combination of both point source and nonpoint source control measures were implemented. The alternative identified a practical and cost-effective combination of point and nonpoint source controls. Under this alternative, it was estimated that 1,054 miles, or 89 percent of the 1,180-stream mile network analyzed, could be expected to meet the national goal of "fishable and swimmable" waters by the year 2000. Similarly, 95 of the 100 major lakes in the Region may be expected to meet the national goal by the year 2000.

*Source: SEWRPC.*

drawing to a close. This facilities planning effort, which is being conducted in part in response to requirements stemming from interstate litigation, will reopen the basic systems level decisions concerning sewer service areas, trunk sewers, and sewage treatment plants in the Milwaukee urbanized area. The resulting Section 201 facilities plan is intended, upon adoption by all of the agencies concerned, to constitute an amendment to the Section 208 regional water quality management plan herein presented.

Nature of Alternatives for Nonpoint (Diffuse) Source Pollution Control

With respect to nonpoint sources of pollution, the alternatives analyses centered on the required reductions in the contribution of pollutants from such sources. An analysis was made of each drainage basin in the Region to determine whether an overall reduction of about 25 percent in pollutant loadings from nonpoint sources when coupled with appropriate point source measures would be sufficient to meet the supporting water quality standards. If the analysis indicated that such a reduction would not be sufficient, then a further analysis was made assuming a reduction of about 50 percent in nonpoint source pollutant loadings. This process was continued until an appropriate minimum level of nonpoint source pollutant reduction was found. In general, these analyses resulted in recommendations for nonpoint source pollutant loading reductions of 25, 50, or 75 percent of uncontrolled loadings, depending upon the characteristics of the individual drainage basins. The analyses recognized that local planning efforts would be necessary to identify the specific measures that should be taken within each drainage basin to achieve the required level of nonpoint source pollutant loading reduction.

Certain minimum nonpoint source control measures, which could achieve up to a 25 percent reduction in anticipated loadings from nonpoint sources, were recommended in both rural and urban areas of the Region as basic soil protection and water quality management measures, and represent the minimum effort recommended toward water quality protection and improvement. The minimum practices recommended for urban areas consist of the following:

- Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning activities.
- Establishment of a litter and pet waste control program to prevent the accumulation of litter and pet wastes.
- The controlled use of fertilizers and pesticides.
- The establishment of a construction erosion control program.
- Improved septic tank system performance monitoring and management.
- Stream bank erosion control practices and other measures in critical areas.
- The establishment of a public educational program to raise the level of awareness of the need for nonpoint source pollution control as an integral element of both public and private land management—or "housekeeping"—practices.
- Industrial and commercial material storage facilities and runoff control measures.

In the rural areas, the recommended minimum nonpoint source pollution control measures consist of the following:

- Basic soil conservation practices, including conservation tillage, pasture management, crop residue management, and contour plowing.
- Livestock waste control.
- Stream bank erosion control practices and other measures in critical areas.
- The controlled use of fertilizers and pesticides.
- The establishment of a public educational program to raise the level of awareness of the need for nonpoint source pollution control as an integral element of land management practices.

The water quality management analysis indicated that, in some areas of the Region, nonpoint source control measures beyond the above-described minimum measures would be required in order to meet the recommended water use objectives. In general, these subareas of the Region are either directly tributary to a lake or contain an unusually high concentration of nonpoint sources of pollution. The additional nonpoint source pollution control measures required in such areas, if urban, include the following:

- Increased expenditures for street sweeping, leaf collection, and catch basin cleaning activities.
- Improved street maintenance and refuse collection and disposal.
- Stream bank protection measures and the creation of vegetative buffer strips along streams.

The additional nonpoint source pollution control measures required in rural areas include the following:

- Additional soil conservation practices, including crop rotation, contour stripcropping, grassed waterways, diversions, wind erosion controls, and gradient and bench terraces.
- Stream bank protection measures and the creation of vegetative buffer strips along streams.
- Base-of-slope detention storage facilities.

It is recommended that minimum soil and water quality management practices be implemented throughout the

Region. However, as noted above, the alternatives investigated under the regional water quality management planning program for additional nonpoint source pollution control beyond such minimum control practices, concerned primarily the level of effort needed rather than specific recommended practices and facilities. The selection of specific combinations of practices and facilities for additional nonpoint source pollution control can only be properly made on the basis of subsequent localized practices planning and preliminary engineering analyses, which must follow the areawide or systems planning effort as one of the first steps toward plan implementation. This was deemed necessary for two reasons. First, the selection of specific land management practices should involve careful consideration of localized topography, soils, land ownership and land use patterns, crops produced, and available land management equipment. Second, proper consideration of such local factors requires active local participation in the refinement and detailing of the areawide plan recommendations.

## CONCLUSION

The water quality management analysis documented in this volume of the three-volume SEWRPC Planning Report No. 30 indicates that, at the present time, the surface waters of the Region rarely meet the national goal of "fishable and swimmable" waters as measured by supporting water quality standards. The analysis further indicates that if steps are not taken to provide for the appropriate abatement of pollution from both point and nonpoint sources, the water quality of the Region will not meet the national goal. Consequently, the development and implementation of a water quality management plan is an essential first step which must be taken if the national goal of "fishable and swimmable" waters is to be met throughout the Region. Analyses conducted in southeastern Wisconsin indicate that, for some surface waters, the "fishable and swimmable" goal probably cannot be met due either to natural conditions, to significant deposits of in-place pollutants, or to the significant altering of the natural characteristics of a stream through concrete channelization. Even these surface waters, however, could support a limited fishery and would be safe for such body contact recreational activities as wading and boating.

The water quality management analysis conducted by the Commission indicated that there are no significant substitutes for stringent levels of control at the major point sources of pollution in the Region. Significant efforts will have to be made to upgrade the quality of sewage treatment plant effluent if the supporting water quality standards are to be met and the use objectives obtained, although in most cases such efforts alone will not be sufficient to fully meet the objectives.

New efforts will have to be mounted to begin abating pollution from nonpoint sources in both rural and urban areas. Such pollution control efforts are likely to be more difficult to bring about than point source pollution control measures and will require an enlightened public for implementation. The specific measures recommended for both nonpoint and point source pollution control in southeastern Wisconsin are set forth in the third and concluding volume of this report.

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# APPENDICES

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## Appendix A

# ROSTERS OF SEWRPC WATER QUALITY MANAGEMENT ADVISORY COMMITTEES

### TECHNICAL ADVISORY COMMITTEE ON AREAWIDE WATER QUALITY MANAGEMENT PLANNING

| | |
|---|---|
| Joel Wesselman* Chairman | Executive Director, Milwaukee-Metropolitan Sewerage Commissions |
| Raymond J. Kipp Vice-Chairman | Dean, College of Engineering, Marquette University |
| Lyman F. Wible Secretary | Chief Environmental Planner, Southeastern Wisconsin Regional Planning Commission |
| Vinton W. Bacon* | Professor, College of Applied Science and Engineering, University of Wisconsin-Milwaukee |
| Anthony S. Bareta | Director, Milwaukee County Planning Commission |
| Kurt W. Bauer* | Executive Director, Southeastern Wisconsin Regional Planning Commission |
| Frank R. Boucher | Director, Environmental Department, Wisconsin Electric Power Company |
| J. R. Castner* | Executive Director, Wisconsin Solid Waste Recycling Authority |
| Frederick H. Chlupp | Land Use and Park Administrator, Washington County |
| Arnold L. Clement* | Planning Director and Zoning Administrator, Racine County |
| Norbert H. Dettmann | Washington County Board Supervisor |
| Alvin A. Erdman | District Conservationist, U. S. Soil Conservation Service, Milwaukee and Waukesha Counties |
| Kent B. Fuller | Chief, Planning Branch, Region V, U. S. Environmental Protection Agency |
| Herbert A. Goetsch | Commissioner of Public Works, City of Milwaukee |
| Thomas N. Hentges | Former Racine County Board Supervisor; Former Chairman, Town of Burlington |
| Lester O. Hoganson | General Manager, Racine Water and Wastewater Utility |
| Helen M. Jacobs* | League of Women Voters |
| Myron E. Johansen* | Former District Conservationist, U. S. Soil Conservation Service, Ozaukee and Washington Counties |
| Leonard C. Johnson | Research and Development Director, Wisconsin Board of Soil and Water Conservation Districts |
| Melvin J. Johnson | Chairman, Town of Norway, Racine County Board Supervisor |
| Elwin G. Leet* | Racine County Agricultural Agent |
| William G. Murphy | Professor, College of Engineering, Marquette University; Chairman, SEWRPC Citizens Advisory Panel for Public Participation on Areawide Wastewater Treatment and Water Quality Management Planning |
| O. Fred Nelson* | Manager, Kenosha Water Utility |
| Wayne A. Pirsig | District Director, Farmers Home Administration, U. S. Department of Agriculture |
| Herbert E. Ripley* | Health Officer, Waukesha County Department of Health |
| Donald A. Roensch | Director of Public Works, City of Mequon |
| Harold F. Ryan | Washington County Board Supervisor |
| Marvin E. Schroeter | Associated Public Works Contractors of Greater Milwaukee, Inc.; Wisconsin Underground Related Material Suppliers |
| Bernard G. Schultz* | Assistant District Director, Southeast District, Wisconsin Department of Natural Resources |
| Walter J. Tarmann* | Executive Director, Park and Planning Commission, Waukesha County |
| Rodney M. Vanden Noven | Director of Public Works, City of Waukesha |
| Emmerich P. Wantschik* | Walworth County Planner |
| Frank A. Wellstein | City Engineer, City of Oak Creek |

*Regional Sludge Management Planning Subcommittee.

## INTERGOVERNMENTAL COORDINATING COMMITTEE ON AREAWIDE WATER QUALITY MANAGEMENT PLANNING

Joel Wesselman . . . . . Executive Director, Milwaukee-Metropolitan Sewerage Commissions
Stephen M. Born . . . . . Director, Office of State Planning and Energy, Wisconsin Department of Administration
Richard E. Carlson . . . . . Chief, Planning Division, Department of the Army, Chicago District, Corps of Engineers
Richard E. Cohen . . . . . Research Analyst, Statistics Division, Wisconsin Department of Agriculture
Kent B. Fuller . . . . . Chief, Planning Branch, Region V, U. S. Environmental Protection Agency
Herbert A. Goetsch . . . . . Commissioner of Public Works, City of Milwaukee
Lester O. Hoganson . . . . . General Manager, Racine Water and Wastewater Utility
George A. James . . . . . Director, Bureau of Local and Regional Planning, Wisconsin Department of Local Affairs and Development
Leonard C. Johnson . . . . . Research and Development Director, Board of Soil and Water Conservation Districts
Thomas A. Kroehn . . . . . Administrator, Division of Environmental Standards, Wisconsin Department of Natural Resources
O. Fred Nelson . . . . . Manager, Kenosha Water Utility
Gerald W. Root . . . . . State Conservationist, U. S. Soil Conservation Service
Harvey E. Wirth . . . . . State Sanitary Engineer, Division of Health, Wisconsin Department of Health and Social Services

## CITIZENS ADVISORY PANEL FOR PUBLIC PARTICIPATION ON AREAWIDE WASTEWATER TREATMENT AND WATER QUALITY MANAGEMENT PLANNING

| | |
|---|---|
| William G. Murphy<br>Chairman | Professor, Marquette University;<br>Engineers and Scientists of Milwaukee |
| Miriam G. Dahl<br>Vice-Chairman | Representative, Izaak Walton League of America,<br>Wisconsin State Division |
| Francis A. Martin<br>Secretary | Representative, Racine-Kenosha Citizens for the Environment |
| Alice G. Altemeier | Designee, League of Women Voters of Wisconsin, Inc. |
| Richard F. Ashley | Designee, Schlitz Audubon Center |
| Cari C. Backes | Chairperson, Equality and Quality of Life (EAQQL) |
| Ralph C. Blum | Representative, American Society of Civil Engineers |
| Lucile S. Bonerz | Designee, Milwaukee Board of Realtors |
| Roger Caron | Executive Director, Kenosha Area Chamber of Commerce |
| Catherine G. Collins | Designee, Wisconsin Academy of Sciences, Arts, and Letters |
| Delbert J. Cook | Representative, Cedar Creek Restoration Council |
| John Drake | Executive Director, Associated Public Works Contractors |
| Tom Eisele | Designee, Lake Michigan Federation |
| Philip J. Fogle | Director, Geneva Lake Watershed Environmental Agency |
| Richard M. Franz | Representative, Ecology Association of New Berlin |
| Norman N. Gill | Executive Director, Citizens Governmental Research Bureau of Milwaukee |
| Allen Goldmann | Supervisor, Ozaukee County; Ozaukee County Air<br>and Water Pollution Study Committee |
| James Gramling | Student, Arrowhead Ecology Club |
| Carroll W. Halsted | Professional Engineer, District 2, Division of Highways,<br>Wisconsin Department of Transportation |
| Kenneth Holtje | Citizen Member, Village of Dousman |
| Robert O. Hussa | President, Citizens for Menomonee River |
| Helen M. Jacobs | President, Southeast Wisconsin Coalition for Clean Air |
| Mrs. Richard J. Jensen | Secretary, Root River Restoration Council, Inc. |
| Marlin Johnson | Field Station Manager, University of Wisconsin-Waukesha Center |
| Paul B. Juhnke | Manager, Metropolitan Milwaukee Association of Commerce,<br>Urban Research and Development |
| Anthony Kau | President, Waukesha County Farm Bureau |
| Richard Lansing | Staff Representative, Plumbers and Gasfitters<br>Local 75, Wisconsin State AFL-CIO |
| Alfred G. Lustig | Designee, Milwaukee River Restoration Council |
| Lawrence R. Olsen | Representative, Kenosha County Farm Bureau |
| Charles Opitz | Representative, Ozaukee County Farm Bureau |
| Wayne M. Paulus | First Wisconsin Mortgage Company |
| Lynn Peterson | President, Racine County Farm Bureau |
| Lanis P. Pfolsgrof | Representative, Sierra Club |
| John R. Rampetsreiter | Designee, District 9, Division of Highways,<br>Wisconsin Department of Transportation |
| Allen E. Reininger | Plumbing and Health Inspector, City of Glendale |
| Annabelle Reuter | Designee, Izaak Walton League |
| Karen Rutz | Representative, Wisconsin Friends of Animals, Inc. |
| Phil Sander | Executive Secretary, Southeastern Wisconsin Sportsman's Federation |
| Dr. Abraham Scherr | Representative, Citizens Regional Environmental Coalition |
| Peter J. Schultz | Representative, Racine Chamber of Commerce |
| William B. N. Schultz | Professional Engineer, Wisconsin Society of Professional Engineers |
| David Sharpe | Community Development Agent, University of Wisconsin-Extension |
| Arthur C. Swanson | Representative, Arrowhead Ecology Club |
| Robert J. Thill | Representative, Ozaukee County Farm Bureau |
| Bruce R. Thompson | Representative, Sierra Club |
| Merv Thompson | Construction Supervisor, Washington County<br>Sedimentation and Erosion Control Project |
| Howard R. Tietz | Representative, Friends of Havenswood |
| Joseph C. Waters | President, Wisconsin Association of Campground Owners |
| Ray Watz | Representative, Ozaukee County Farm Bureau |
| Kenneth Weddig | Representative, Washington County Recreation and Resource Council |
| John A. White | Maintenance Engineer, District 2, Division of Highways,<br>Wisconsin Department of Transportation |
| Steven Woll | Executive Director, Metropolitan Builders Association of Greater Milwaukee |

## Appendix B

## ROSTERS OF SELECTED SEWRPC ADVISORY COMMITTEES

### TECHNICAL COORDINATING AND ADVISORY COMMITTEE ON REGIONAL LAND USE-TRANSPORTATION PLANNING

The Technical Coordinating and Advisory Committee on Regional Land Use-Transportation Planning is divided into several functional subcommittees. Members of the Committee often serve on more than one subcommittee. The following key identifies the various functional subcommittees: 1) Land Use Subcommittee; 2) Highway Subcommittee; 3) Socioeconomic Subcommittee; 4) Natural and Recreation-Related Resources Subcommittee; 5) Transit Subcommittee; 6) Utilities Subcommittee; and 7) Traffic Studies, Models, and Operations Subcommittee.

Stanley E. Altenbern (5) . . . . . . . . President, Wisconsin Coach Lines, Inc., City of Waukesha
Anthony S. Bareta (3) . . . . . . . . Director, Milwaukee County Planning Commission
John M. Bennett (1,4) . . . . . . . . City Engineer, City of Franklin
Robert P. Birchler (2) . . . . . . . . City Engineer, City of Burlington
Stephen M. Born (1) . . . . . . . . Director, State Planning Office, Wisconsin Department of Administration
Richard Brandt (1) . . . . . . . . Manager, Energy Requirements, Wisconsin Gas Company, City of Milwaukee
Robert W. Brannan (2,5,7) . . . . . . . . Deputy Director, Department of Public Works, Milwaukee County
Donald M. Cammack (7) . . . . . . . . Chief Planning Engineer, Division of Aeronautics, Wisconsin Department of Transportation
Frederick H. Chlupp (1,4) . . . . . . . . Land Use and Park Administrator, Washington County
Thomas R. Clark (2,5,7) . . . . . . . . Chief Planning Engineer, District 2, Division of Highways, Wisconsin Department of Transportation
Arnold L. Clement (1,2) . . . . . . . . Planning Director and Zoning Administrator, Racine County
Lucien M. Darin (2) . . . . . . . . Director of Public Works, City of Hartford
Vencil F. Demshar (2) . . . . . . . . County Highway Commissioner, Waukesha County
Russell A. Dimick (2) . . . . . . . . City Engineer, City of Cedarburg
Arthur D. Doll (1) . . . . . . . . Director, Bureau of Planning, Wisconsin Department of Natural Resources
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## Appendix C

## ALTERNATIVE LAKE WATER QUALITY PLAN ELEMENTS

### INTRODUCTION

This appendix presents an evaluation of the existing and expected future pollution sources and water quality conditions of the 100 major lakes in the Region, i.e., those lakes having a water surface area of at least 50 acres. In addition, alternative diffuse source pollution control measures for the direct tributary drainage areas of the lakes are presented, together with potential lake rehabiliation techniques. The major lakes have a combined surface water area of 36,369 acres and a combined direct tributary drainage area of 265,375 acres, or about 15 percent of the Region. Of the 100 lakes, one—Lake Geneva in Walworth County—is recommended to be classified for the maintenance of a trout fishery and aquatic life and recreational use; four—Crooked Lake in Waukesha County and Echo Lake, Kee Nong Go Mong Lake, and Buena Lake in Racine County—are recommended to be classified for warmwater fish and aquatic life and limited recreational use; and one—Mud Lake in Ozaukee County—is recommended to be classified for a limited fishery and limited recreational use. The remaining 94 major lakes in the Region are classified for warmwater fish and aquatic life, and recreational use.

Table C-1

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BENET/SHANGRILA LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 154 acres |
| Direct Tributary Drainage Area | 328 acres |
| Shoreline | 6.2 miles |
| Depth | |
| Maximum | 24 feet |
| Mean | 4.7 feet |
| Volume | 748 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 710 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; high nutrient concentrations; dissolved oxygen depletion in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.50 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

The 100 major lakes within southeastern Wisconsin are located within four of the 12 major watersheds, with four lakes in the Des Plaines River watershed, 46 lakes in the Fox River watershed, 12 lakes in the Milwaukee River watershed, and 38 lakes in the Rock River watershed. In the discussion following, the 100 major lakes are presented alphabetically by watershed.

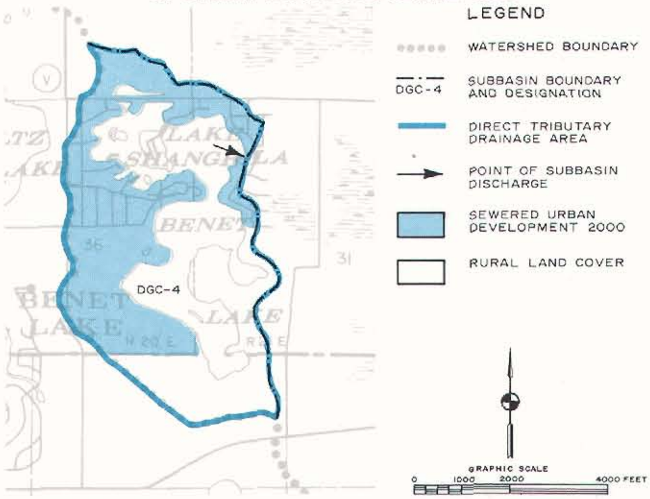
### DES PLAINES RIVER WATERSHED

Benet/Shangrila Lake

Benet/Shangrila Lake is a 154-acre lake located in the Towns of Bristol and Salem in Kenosha County. The lake drains to a wetland area directly east of the lake and eventually to the Dutch Gap Canal. Certain geomorphological characteristics of Benet/Shangrila Lake are set forth in Table C-1, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-1 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-1, all of the existing urban land in the tributary water-

Map C-1

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF BENET/SHANGRILA LAKE: 2000




Benet/Shangrila Lake has a direct tributary drainage area of about 328 acres. About 132 acres, or 40 percent of the drainage area, are planned to be in rural land cover, and 196 acres, or 60 percent, to be in urban land cover. Over the planning period an average of about one acre may be expected to be converted annually to urban land cover. The elimination of phosphorus loads from malfunctioning septic tank systems will be necessary to sufficiently reduce pollutant runoff to the lake. To provide water quality control, a combination of minimum rural land management practices and urban management practices—including construction erosion controls—should be implemented in the lake drainage area.

*Source: SEWRPC.*

shed area is proposed to be served by sanitary sewers by the year 2000. As of 1975 an estimated 203 privately owned onsite sewage disposal systems—all of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-2, all sources contribute about 779 pounds of phosphorus annually to Benet/Shangrila Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also, as indicated in Table C-2, urban land uses in the watershed are expected to increase by about 16 percent under plan year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be reduced to about 244 pounds. The addition of sanitary sewers within the watershed

### Table C-2

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BENET/SHANGRILA LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 168 | 79 | 10 | 195 | 93 | 38 |
| Land under Development—Construction Activities (acres) | – | – | – | 1 | 45 | 18 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 203 | 588 | 76 | – | – | – |
| Rural Land Cover (acres) | 160 | 35 | 4 | 132 | 29 | 12 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 154 | 77 | 10 | 154 | 77 | 32 |
| Total | – | 779 | 100 | – | 244 | 100 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

### Table C-3

### WATER QUALITY MANAGEMENT MEASURES FOR BENET/SHANGRILA LAKE IN KENOSHA COUNTY

| Alternative Plan Element Description | Estimated Cost | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital: 1980-2000 | Average Annual Operation and Maintenance 1980-2000 | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect Public health and drinking water supplies; reduce nutrient concentrations | – |
| Minimum Rural Land Management Practices | $ <100 | $ 300 | $ <100 | $ 2,800 | $ 2,900 | $ <100 | $ 200 | $ 200 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 50 |
| Construction Erosion Control Practices[c] | 143,200 | 1,200 | 107,500 | 19,500 | 127,000 | 6,800 | 1,200 | 8,000 | | |
| Low Cost Urban Land Practices | Minimal | 300 | Minimal | 4,400 | 4,400 | Minimal | 300 | 300 | | |
| Total | $ 143,300 | $ 1,800 | $ 107,600 | $ 26,700 | $ 134,300 | $ 6,900 | $ 1,700 | $ 8,500 | | |
| Macrophyte Harvesting[d] | 23,300 | 3,300 | 17,400 | 52,000 | 69,400 | 1,100 | 3,300 | 4,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[e] | 600 | <100 | 400 | 200 | 600 | <100 | <100 | <100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 300 to 15,400 | – | 200 to 11,500 | – | 200 to 11,500 | <100 to 700 | – | <100 to 700 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,i] | 308,000 | – | 230,200 | – | 230,200 | 14,600 | – | 14,600 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[h,i] | 2,558,500 | – | 1,912,000 | – | 1,912,000 | 121,300 | – | 121,300 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Des Plaines subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Des Plaines River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Benet/Shangrila Lake drainage basin include a capital cost over the period of 1975-2000 of $84,000, an average annual operation and maintenance cost of $6,700, and a total 50-year present worth cost of $153,000.*

[c] *Cost estimated to control erosion from the estimated one acre of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *Cost estimated to harvest macrophytes from the 25 acres of Benet/Shangrila Lake subject to excessive macrophyte growth.*

[e] *Cost estimated to aerate the entire hypolimnion of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 4.7 feet.*

[i] *Actual costs may be higher depending upon lake depth, sediment type, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

will eliminate all septic tank systems. Loadings from urban land use activities are expected to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.06 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Benet/Shangrila Lake which meet or exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made, and a set of recommended measures was identified. These measures are set forth in Table C-3, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: the provision of sanitary sewer service, the implementation of basic soil conservation practices to reduce pollutant runoff from rural lands, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned point and diffuse source controls. Macrophyte harvesting may be necessary in order to maintain open water areas for recreational purposes. Alternative restoration measures, as set forth in Table C-3, may include sediment covering, hypolimnetic aeration, nutrient inactivation, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Benet/Shangrila Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Benet/Shangrila Lake would entail a total capital cost of about $143,300, and an average annual operation and maintenance cost of about $1,800. The total 50-year present worth cost of these nonpoint source control measures (useful in comparing the long term costs of alternative control measures) is $134,300, with an equivalent annual cost of $8,500. The estimated capital cost of lake rehabilitation techniques ranges from $300 for nutrient inactivation to $2,558,000 for dredging. The total present worth costs of these lake rehabilitation techniques range from $200 for nutrient inactivation to $1.9 million for dredging.

George Lake

George Lake is a 59-acre lake located in the Town of Bristol in Kenosha County. The lake drains to the Dutch Gap Canal. Certain geomorphological characteristics of George Lake are set forth in Table C-4, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-2 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-2, most of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 56 privately owned onsite sewage disposal systems—15 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-5, all sources contribute about 1,130 pounds of phosphorus annually to George Lake. The major source of phosphorus in the lake watershed is livestock operations. Also, as indicated in Table C-5, urban land uses in the watershed are expected to increase by about two-fold under plan year 2000 land cover conditions. The estimated annual total phosphorus load

Table C-4

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF GEORGE LAKE

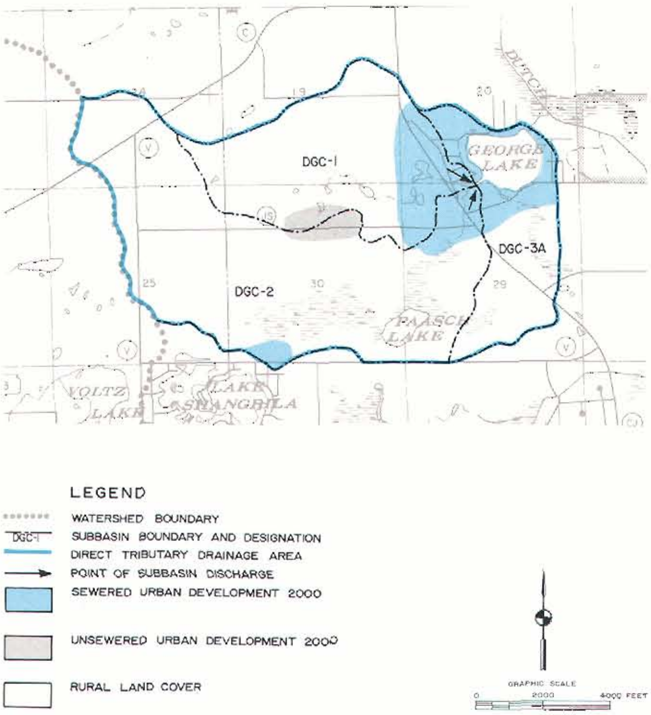
| Characteristic | Description |
|---|---|
| Surface Area | 59 acres |
| Direct Tributary Drainage Area | 1,911 acres |
| Shoreline | 1.18 miles |
| Depth | |
| Maximum | 16 feet |
| Mean | 6.4 feet |
| Volume | 389.4 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 434 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.68 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Map C-2

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF GEORGE LAKE: 2000




George Lake has a direct tributary drainage area of about 1,911 acres. About 1,564 acres, or 82 percent of the drainage area, are planned to be in rural land cover, and 347 acres, or 18 percent, to be in urban land cover. Over the planning period an average of about nine acres may be expected to be converted annually to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of rural land management practices—including especially the proper management of livestock wastes—and low-cost urban management practices—including construction erosion controls and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

to the lake under anticipated year 2000 conditions is about 1,113 pounds. Unless phosphorus loadings are reduced by the implementation of nonpoint source control measures, livestock, rural land, and construction activities are expected to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from the water quality simulation model, is 0.10 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in George Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Table C-5

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO GEORGE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 120 | 32 | 2.8 | 338 | 58 | 5.2 |
| Land under Development—Construction Activities (acres) | 9 | 198 | 17.5 | 9 | 198 | 17.8 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 15 | 32 | 2.8 | 15 | 32 | 2.9 |
| Rural Land Cover (acres) | 1,782 | 348 | 31.0 | 1,564 | 305 | 27.4 |
| Livestock Operations (animal units) | 186 | 491 | 43.4 | 186 | 491 | 44.1 |
| Atmospheric Contribution (acres of receiving surface water) | 59 | 29 | 2.5 | 59 | 29 | 2.6 |
| Total | - | 1,130 | 100.0 | - | 1,113 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made, and a set of recommended measures was identified. These measures are set forth in Table C-6, along with the associated costs and anticipated effectiveness. Controlling livestock contributions appears to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service; improved septic tank management; measures to reduce pollutant runoff from rural lands by 50 percent; low-cost measures to reduce pollutant runoff from urban lands; and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures, as set forth in Table C-6, may include dredging, sediment covering, aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in George Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to George Lake would entail a total capital cost of about $452,900, and an average operation and maintenance cost of about $10,700. The total 50-year present worth cost of these nonpoint source control measures is

## Table C-6

## WATER QUALITY MANAGEMENT MEASURES FOR GEORGE LAKE IN KENOSHA COUNTY

| Alternative Plan Element Description | Estimated Cost: Total Capital: 1980-2000 | Estimated Cost: Average Annual Operation and Maintenance 1980-2000 | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | — |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | |
| Livestock Waste Control[d] | $ 16,400 | $ 1,400 | $ 12,200 | $ 16,400 | $ 28,600 | $ 800 | $ 1,000 | $ 1,800 | | |
| Rural Land Management Practices and Streambank Protection[e] | 20,700 | 5,300 | 15,400 | 65,100 | 80,500 | 1,000 | 4,100 | 5,100 | | |
| Construction Erosion Control Practices[f] | 415,800 | 3,600 | 312,100 | 56,700 | 368,800 | 19,800 | 3,600 | 23,400 | | |
| Low Cost Urban Land Management Practices | – | 400 | – | 5,600 | 5,600 | – | 400 | 400 | | |
| Total | $ 452,900 | $ 10,700 | $ 339,700 | $ 143,800 | $ 483,500 | $ 21,600 | $ 9,100 | $ 30,700 | | 80 |
| Macrophyte Harvesting[g] | 37,300 | 5,200 | 27,900 | 82,000 | 109,900 | 1,800 | 5,200 | 7,000 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Total Aeration[h] | 5,000 | 100 | 3,700 | 1,600 | 5,300 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[i] | 5,900 | – | 4,400 | – | 4,400 | – | 300 | 300 | Accelerate lake improvement; prevent release of nutrient from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[j,l] | 118,000 | – | 88,200 | – | 88,200 | 5,600 | – | 5,600 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[k,l] | 799,400 | – | 597,400 | – | 597,400 | 37,900 | – | 37,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

*[a] The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Des Plaines River subregional area.*

*[b] Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Des Plaines River subregional area. Costs represent the estimated cost of wastewater treatment and trunk sewer facilities for the Bristol-George Lake sewer service area prorated, based upon the population of the lake watershed to the total sewered population of the service area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the George Lake drainage basin include a capital cost over the period of 1975-2000 of $284,000; an average annual operation and maintenance cost of $2,100; and a total 50-year present worth cost of $312,800.*

*[c] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of George Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the George Lake drainage basin include a capital cost over the period of 1975-2000 of $67,500, an average annual operation and maintenance cost of $1,500; and a total 50-year present worth cost of $87,800.*

*[d] If adequate livestock waste control is determined following a field inspection by soil conservation representatives, the above-cited control costs may be substantially reduced or eliminated.*

*[e] Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse source pollutant loads, including costs for minimum rural land management practices.*

*[f] Cost estimated to control erosion from the estimated nine acres of land estimated to be annually undergoing construction activity in the George Lake watershed.*

*[g] Cost estimated to harvest macrophytes from the 40 acres of George Lake subject to excessive macrophyte growth.*

*[h] Cost estimated to aerate about 25 acres of the lake.*

*[i] The cost for nutrient inactivation is for treating the entire lake with alum.*

*[j] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[k] Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 6.4 feet.*

*[l] Costs may be higher depending upon lake depth, sediment type, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

$483,500, with an equivalent annual cost of $30,700. The capital cost of rehabilitation techniques, if found necessary, would range from $5,000 for total aeration to $799,400 for dredging. The total present worth costs of these lake rehabilitation techniques range from $4,400 for nutrient inactivation to $597,400 for dredging.

Hooker Lake

Hooker Lake is an 88-acre lake located in the Town of Salem in Kenosha County. The lake drains to the Salem Branch of Brighton Creek. Certain geomorphological characteristics of Hooker Lake are set forth in Table C-7, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-3 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-3, most of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 23 privately owned onsite sewage disposal systems—14 of which were located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-8, all sources contribute about 970 pounds of phosphorus annually to Hooker Lake. The major sources of phosphorus in the lake watershed are livestock operations, runoff from construction activities, and runoff from rural land. Also, as indicated in Table C-8, urban land uses in the watershed are expected to increase by about 62 percent under plan year 2000 land cover conditions.

Table C-7

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF HOOKER LAKE

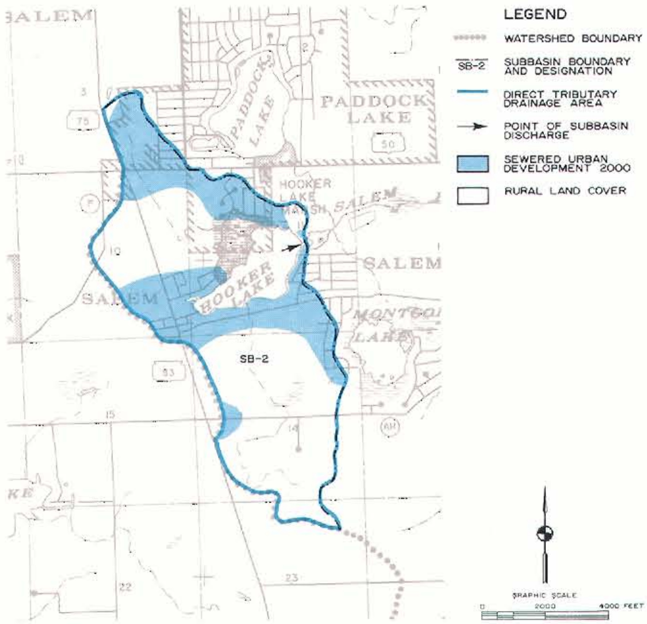
| Characteristic | Description |
|---|---|
| Surface Area | 88 acres |
| Direct Tributary Drainage Area | 1,133 acres |
| Shoreline | 1.90 miles |
| Depth | |
| Maximum | 24 feet |
| Mean | 11.3 feet |
| Volume | 983 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 602 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; moderately high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Map C-3

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF HOOKER LAKE: 2000




Hooker Lake has a direct tributary drainage area of about 1,133 acres. About 737 acres, or 65 percent of the drainage area, are planned to be in rural land cover, and 396 acres, or 35 percent, to be in urban land cover. Over the planning period an average of about five acres may be expected to be converted annually to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and urban land management practices—including construction erosion controls and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-8

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO HOOKER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 242 | 106 | 10.9 | 391 | 191 | 19.2 |
| Land under Development—Construction Activities (acres) | 5 | 236 | 24.2 | 5 | 236 | 23.6 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 14 | 40 | 4.1 | 8 | 23 | 2.3 |
| Rural Land Cover (acres) | 886 | 224 | 23.0 | 737 | 181 | 18.1 |
| Livestock Operations (animal units) | 49 | 323 | 33.3 | 49 | 323 | 32.4 |
| Atmospheric Contribution (acres of receiving surface water) | 87 | 44 | 4.5 | 87 | 44 | 4.4 |
| Total | – | 973 | 100.0 | – | 998 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Table C-9

## WATER QUALITY MANAGEMENT MEASURES FOR HOOKER LAKE IN KENOSHA COUNTY

| Alternative Plan Element Description | Estimated Cost | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital: 1980-2000 | Average Annual Operation and Maintenance 1980-2000 | *Capital* | *Operation and Maintenance* | *Total* | *Capital* | *Operation and Maintenance* | *Total* | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | |
| Livestock Waste Control | $ 4,300 | $ 400 | $ 3,200 | $ 4,300 | $ 7,500 | $ 200 | $ 300 | $ 500 | | |
| Rural Land Management Practices[d] | 96,600 | 12,600 | 81,300 | 63,500 | 144,800 | 5,200 | 4,000 | 9,200 | | |
| Construction Erosion Control Practices[e] | 231,000 | 2,000 | 173,400 | 31,500 | 204,900 | 11,000 | 2,000 | 13,000 | | 80 |
| Low Cost Urban Land Management Practices | – | 500 | – | 7,700 | 7,700 | – | 500 | 500 | | |
| Additional Urban Land Management Practices[f] | 10,900 | 5,600 | 7,800 | 65,600 | 73,400 | 500 | 4,200 | 4,700 | | |
| Total | $ 342,800 | $ 21,100 | $ 265,700 | $ 172,600 | $ 438,300 | $ 16,900 | $ 11,000 | $ 27,900 | | |
| Macrophyte Harvesting[g] | 23,300 | 3,300 | 17,400 | 52,000 | 69,400 | 1,100 | 3,300 | 4,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[h] | 1,600 | <100 | 1,200 | 600 | 1,800 | 100 | <100 | 100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[i] | 800 to 8,800 | – | 600 to 6,600 | – | 600 to 6,600 | <100 to 400 | – | <100 to 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[j,l] | 176,000 | – | 131,500 | – | 131,500 | 8,300 | – | 8,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[k,l] | 525,200 | – | 392,500 | – | 392,500 | 24,900 | – | 24,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

*[a] The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Des Plaines River subregional area.*

*[b] Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Des Plaines River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Hooker Lake drainage basin include a capital cost over the period of 1975-2000 of $184,000; an average annual operation and maintenance cost of $6,200; and a total 50-year present worth cost of $200,000.*

*[c] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Hooker Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Hooker Lake drainage basin include a capital cost over the period of 1980-2000 1975-2000, an average annual operation and maintenance cost of $600; and a total 50-year present worth cost of $43,300.*

*[d] Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads.*

*[e] Cost estimated to control erosion from the estimated five acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*[f] Urban land management practices necessary to achieve a 50 percent reduction in urban diffuse source pollutant loads.*

*[g] Cost estimated to harvest macrophytes from the 25 acres of Hooker Lake subject to excessive macrophyte growth.*

*[h] Cost estimated to aerate the entire hypolimnion of the lake.*

*[i] The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

*[j] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[k] Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 11.3 feet.*

*[l] Cost may be higher depending upon lake depth, sediment type, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The benefits of any proposed extension of the sewer service area may be offset by increased urban runoff, with the annual total phosphorus load under year 2000 conditions estimated at about 1,000 pounds. Unless phosphorus loadings are reduced by the implementation of nonpoint source control measures, livestock operations and construction activities are expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.09 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Hooker Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake was made, and a set of recommended measures was identified. These measures are set forth in Table C-9, along with the associated costs and anticipated effectiveness. Controlling livestock contributions appears to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service; improved septic tank management; measures to reduce pollutant runoff from rural lands by 75 percent; low-cost measures to reduce pollutant runoff from urban lands; measures to reduce pollutant runoff from urban lands by 50 percent; and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures, as set forth in Table C-9, may include dredging, sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Hooker Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control nutrient inputs to Hooker Lake would entail a total capital cost of about $342,800, and an average annual operation and maintenance cost of about $21,100. The total 50-year present worth cost of these nonpoint source control measures is $438,300, with an equivalent annual cost of $27,900. The capital cost of rehabilitation techniques, if found necessary, would range from $800 for nutrient inactivation to $525,200 for dredging. The total present worth costs of these lake rehabilitation techniques range from $600 for nutrient inactivation to $392,500 for dredging.

Paddock Lake

Paddock Lake is a 112-acre lake located in the Town of Salem in Kenosha County. The lake drains to the Salem Branch of Brighton Creek. Certain geomorphological characteristics of Paddock Lake are set forth in Table C-10, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-4 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-4, most of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, fewer than five privately owned onsite sewage disposal systems—two located in areas covered by soils having severe and very severe limitations for the use of such systems—were estimated to be in operation in the lake watershed area.

**Table C-10**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PADDOCK LAKE**

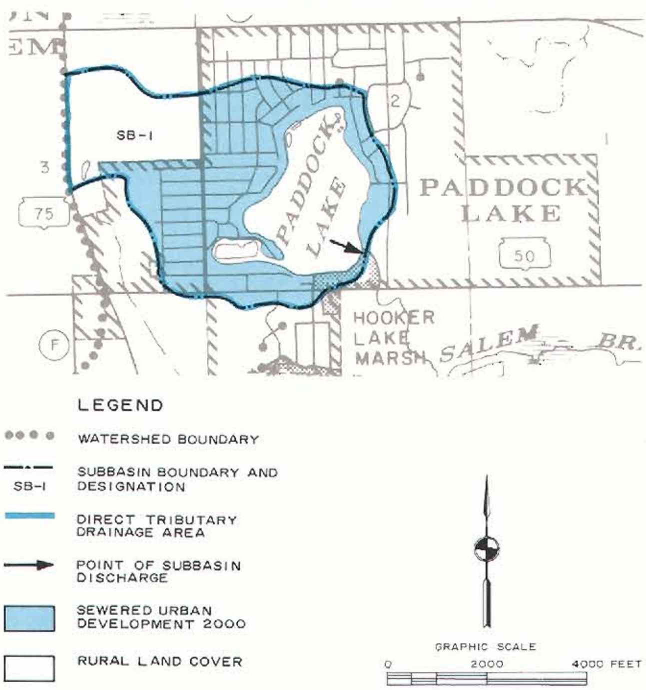
| Characteristic | Description |
|---|---|
| Surface Area | 112 acres |
| Direct Tributary Drainage Area | 362 acres |
| Shoreline | 3.42 miles |
| Depth | |
| Maximum | 32 feet |
| Mean | 11.4 feet |
| Volume | 1,277 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,406 persons |
| General Existing Water Quality Conditions: | Localized excessive macrophyte growth; low oxygen levels in the hypolimnion during summer |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-4

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PADDOCK LAKE: 2000




Paddock Lake has a direct tributary drainage area of about 362 acres. About 54 acres, or 15 percent of the drainage area, are planned to be in rural land cover, and 308 acres, or 85 percent, to be in urban land cover. Over the planning period an average of less than one acre may be expected to be converted annually to urban land cover. It is estimated that no reduction in existing loadings from nonpoint source pollutant runoff will be necessary in the drainage area, but that the water quality of the lake should be protected by basic land management practices. To provide minimum water quality control, a combination of minimum rural land management practices and minimum urban land management practices—including construction erosion controls—should be implemented in the lake drainage area.

*Source: SEWRPC.*

As indicated in Table C-11, all sources contribute about 200 pounds of phosphorus annually to Paddock Lake. The major source of phosphorus in the lake watershed is urban land runoff. Also, as indicated in Table C-11, urban land uses in the watershed are expected to increase 23 percent under plan year 2000 land cover conditions, and the sewer service area is proposed to be extended. Unless phosphorus loadings are reduced by the implementation of nonpoint source control measures, urban runoff is expected to continue to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational

Table C-11

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PADDOCK LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 250 | 98 | 49.7 | 308 | 124 | 59.6 |
| Land under Development—Construction Activities (acres) | 0.2 | 11 | 5.6 | 0.2 | 11 | 5.3 |
| Onsite Sewage Disposal Septic Tank Systems[b] | less than 5 | 3 | 1.5 | less than 5 | 3 | 1.4 |
| Rural Land Cover (acres) | 112 | 29 | 14.7 | 54 | 14 | 6.7 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 112 | 56 | 28.4 | 112 | 56 | 27.0 |
| Total | – | 197 | 100.0 | – | 208 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Paddock Lake which do not exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-12, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: the provision of sanitary sewer service, improved septic tank management, implementation of basic soil conservation practices to reduce pollutant runoff from rural lands, and low-cost measures to reduce pollutant runoff from urban lands. If nutrient loadings to the lake are reduced by the actions noted above, the sediments and other pollutants which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures, as set forth in Table C-12, include nutrient inactivation and hypolimnetic aeration. Dredging to remove nutrients and sediment deposits, and to deepen the lake to enhance the intended uses, may be appropriate and has been proposed locally. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Paddock Lake requires that the recommended level of nutrient input reductions be achieved.

## Table C-12

## WATER QUALITY MANAGEMENT MEASURES FOR PADDOCK LAKE IN KENOSHA COUNTY

| Alternative Plan Element Description | Estimated Cost: Total Capital: 1980-2000 | Estimated Cost: Average Annual Operation and Maintenance 1980-2000 | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 25 |
| Minimum Rural Land Management Practices | $ <100 | $ 200 | $ <100 | $ 1,900 | $ 2,000 | $ <100 | $ 100 | $ 100 | | |
| Construction Erosion Control Practices[d] | 11,400 | 100 | 8,500 | 1,500 | 9,800 | 500 | 100 | 600 | | |
| Low Cost Urban Land Management Practices | – | 500 | – | 6,700 | 6,700 | – | 400 | 400 | | |
| Total | $ 11,500 | $ 800 | $ 8,600 | $ 10,100 | $ 18,700 | $ 500 | $ 600 | $ 1,100 | | |
| Macrophyte Harvesting[e] | 37,300 | 5,200 | 27,900 | 82,000 | 109,900 | 1,800 | 5,200 | 7,000 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 4,600 | 100 | 3,400 | 1,600 | 5,000 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 2,300 to 11,200 | – | 1,700 to 8,400 | – | 1,700 to 8,400 | 100 to 500 | – | 100 to 500 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Dredging[h,i] | 650,400 | – | 486,000 | – | 486,000 | 30,800 | – | 30,800 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Des Plaines River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Des Plaines River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up operation and maintenance in the Paddock Lake drainage basin include a capital cost over the period of 1975-2000 of $136,000, an average annual operation and maintenance cost of $13,700, and a total 50-year present worth cost of $292,400.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Paddock Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Paddock Lake drainage basin include a capital cost over the period of 1975-2000 of $4,500, an average annual operation and maintenance cost of $200, and a total 50-year present worth cost of $7,900.*

[d] *Cost estimated to control erosion from the estimated 0.2 acre of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 40 acres of Paddock Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 11.4 feet.*

[i] *Cost may be higher depending upon lake depth, sediment type, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Paddock Lake would entail a total capital cost of about $11,500, and an average annual operation and maintenance cost of about $800. The total 50-year present worth cost of these nonpoint source control measures (useful in comparing the long-term costs of alternative control measures) is $18,700, with an equivalent annual cost of $1,100. The capital cost of these rehabilitation techniques, if found necessary, would range from $2,300 for nutrient inactivation to $650,400 for dredging. The present worth costs of these lake rehabilitation techniques range from $1,700 for nutrient inactivation to $486,000 for dredging.

## Army Lake

Army Lake is a 78-acre lake located in the Town of East Troy in Walworth County. Certain geomorphological characteristics of Army Lake are set forth in Table C-13, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-5 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-5, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 43 privately owned onsite sewage disposal systems—30 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-14, all sources contribute about 1,510 pounds of phosphorus annually to Army Lake. The major source of phosphorus in the lake watershed is livestock operations. Also, as indicated in Table C-14, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock operations may be expected to continue to be

Table C-13

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF ARMY LAKE

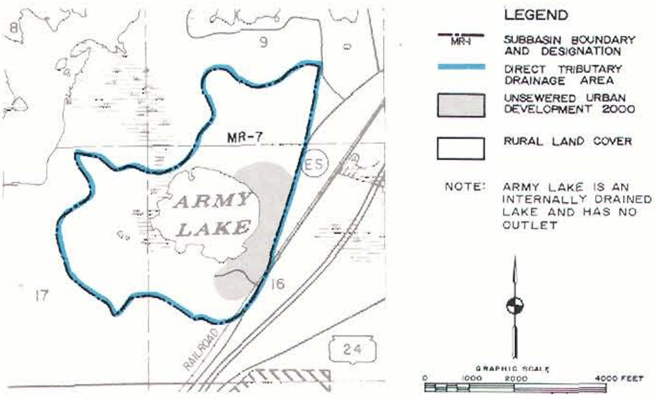
| Characteristic | Description |
|---|---|
| Surface Area | 78 acres |
| Direct Tributary Drainage Area | 356 acres |
| Shoreline | 1.5 miles |
| Depth | |
| Maximum | 17 feet |
| Mean | 8 feet |
| Volume | 625 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 147 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.42 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-5

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF ARMY LAKE PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF ARMY LAKE: 2000




Army Lake has a direct tributary drainage area of about 356 acres. About 266 acres, or 75 percent of the drainage area, are planned to be in rural land cover, and 90 acres, or 25 percent, to be in urban land cover. Over the planning period none of the watershed area is expected to be converted to urban land cover. It is estimated that a 90 percent reduction in nonpoint pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-14

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO ARMY LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 90 | 24 | 1.6 | 90 | 24 | 1.6 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 30 | 87 | 5.8 | 30 | 87 | 5.8 |
| Rural Land Cover (acres) | 266 | 40 | 2.6 | 266 | 40 | 2.6 |
| Livestock Operations (animal units) | 200 | 1,320 | 87.4 | 200 | 1,320 | 87.4 |
| Atmospheric Contribution (acres of receiving surface water) | 78 | 39 | 2.6 | 78 | 39 | 2.6 |
| Total | – | 1,510 | 100.0 | – | 1,510 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.19 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use objectives. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Army Lake which exceed the recommended level for recreational use and for the maintenance of a warm water fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made, and a set of recommended measures was identified. These measures are set forth in Table C-15, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management; minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices; and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures as set forth in Table C-15 may include dredging, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Army Lake requires that the recommended level of nutrient input reductions be achieved.

**Table C-15**

**WATER QUALITY MANAGEMENT MEASURES FOR ARMY LAKE IN WALWORTH COUNTY**

| Alternative Plan Element Description | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis, Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Economic Analysis, Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | |
| Livestock Waste Control | $ 17,600 | $ 1,500 | $ 13,200 | $ 17,700 | $ 30,900 | $ 800 | $ 1,100 | $ 1,900 | | |
| Minimum Rural Conservation Practices | < 100 | 500 | < 100 | 5,700 | 5,800 | < 100 | 400 | 500 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 2,200 | 2,200 | Minimal | < 100 | < 100 | | |
| Total | 17,700 | 2,100 | 13,300 | 25,600 | 38,900 | 900 | 1,600 | 2,500 | | 90 |
| Nutrient Inactivation[b] | 7,800 | – | 5,800 | – | 5,800 | 400 | – | 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[c,e] | 156,000 | | ,116,600 | | 116,600 | 7,400 | | 7,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[d,e] | 880,700 | – | 658,200 | – | 658,200 | 41,800 | – | 41,800 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Army Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Army Lake drainage basin include a capital cost over the period of 1975-2000 of $135,000, an average annual operation and maintenance cost of $1,600, and a total 50-year present worth cost of $130,800.*

[b] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[c] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[d] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 8 feet.*

[e] *The costs of sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Army Lake would entail a total capital cost of about $17,700 and an average annual operation and maintenance cost of about $2,100. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $38,900 with an equivalent annual cost of $2,500. The capital cost of rehabilitation techniques, if found necessary, would range from $7,800 for nutrient inactivation to $880,700 for dredging. The total present worth cost of these lake rehabilitation techniques would range from $5,800 for nutrient inactivation to $658,200 for dredging.

Benedict Tombeau Lake

Benedict Tombeau Lake is a 129-acre lake located in the Town of Randall in Kenosha County, and the Town of Bloomfield in Walworth County. The lake drains to the east branch of Nippersink Creek and eventually into the Fox River in Illinois. Certain geomorphological characteristics of Benedict Tombeau Lake are set forth in Table C-16, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-6 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-6 none of the urban land in the tributary watershed area is proposed to be

Table C-16

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BENEDICT-TOMBEAU LAKE

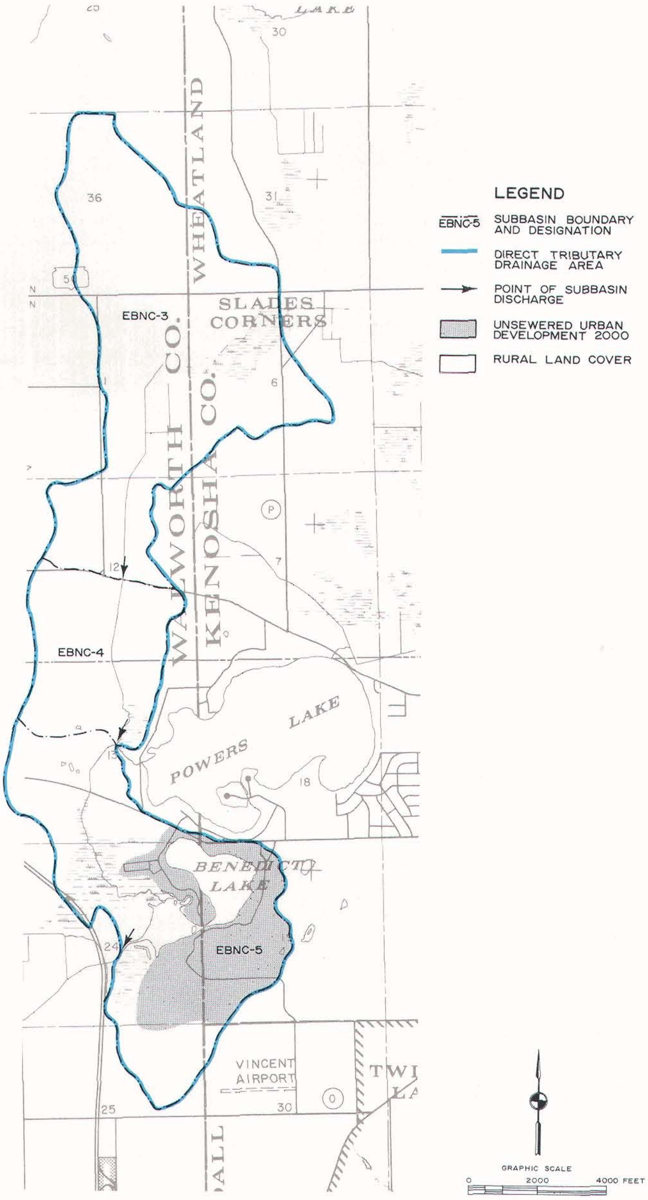
| Characteristic | Description |
|---|---|
| Surface Area . . . . . . . . . . . . | 129 acres |
| Direct Tributary Drainage Area . . . . . . . . . . . . . . . . | 2,589 acres |
| Shoreline . . . . . . . . . . . . . . | 3.7 miles |
| Depth | |
| Maximum . . . . . . . . . . . | 37 feet |
| Mean . . . . . . . . . . . . . . . | 15.4 feet |
| Volume . . . . . . . . . . . . . . . | 1,888 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] . . . . . | 374 persons |
| General Existing Water Quality Conditions: | Excessive macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Map C-6

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF BENEDICT/TOMBEAU LAKE: 2000




Benedict/Tombeau Lake has a direct tributary drainage area of about 2,589 acres. About 2,219 acres, or 85 percent of the drainage area, are planned to be in rural land cover, and 370 acres, or 15 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed is expected to be converted to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

served by sanitary sewers by the year 2000. As of 1975, an estimated 113 provately owned onsite sewage disposal systems—65 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-17, all sources combined contribute about 3,555 pounds of phosphorus annually to Benedict Tombeau Lake. The major source of phosphorus in the lake watershed is runoff from livestock operations. Also, as indicated in Table C-17, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock operations may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.21 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a recreational use and warmwater fishery and aquatic life classification. Benedict Tombeau Lake consits of two major basins, connected by a channel. The Tombeau lake basin, which comprises about 40 percent of the total lake area and about 36 percent of the total lake volume, receives over 90 percent of the total phosphorus load to the lake. The Benedict lake basin receives a relatively small portion of the total pollutant load. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Benedict Tombeau Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

**Table C-17**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BENEDICT-TOMBEAU LAKES: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 370 | 73 | 2.0 | 370 | 73 | 2.0 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 65 | 188 | 5.3 | 65 | 188 | 5.3 |
| Rural Land Cover (acres) | 2,219 | 339 | 9.6 | 2,219 | 339 | 9.6 |
| Livestock Operations (animal units) | 438 | 2,890 | 81.3 | 438 | 2,890 | 81,3 |
| Atmospheric Contribution (acres of receiving surface water) | 129 | 65 | 1.8 | 129 | 65 | 1.8 |
| Total | – | 3,555 | 100.0 | – | 3,555 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC*

The measures available for controlling nonpoint source pollution together with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made, and a set of recommended measures was identified. These measures are set forth in Table C-18, along with the associated costs and anticipated effectiveness. Controlling livestock contributions appears to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include the following: improved septic tank management; measures to reduce pollutant runoff from rural lands by 50 percent; and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the abovementioned diffuse source controls. Alternative restoration measures as set forth in Table C-18, may include sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Benedict Tombeau Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Benedict Tombeau Lake would entail a total capital cost of about $68,700, and an average annual operation and maintenance cost of about $11,700. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $193,700 with an equivalent annual cost of $12,300. If in addition rehabilitation techniques are found necessary the capital cost of these alternatives would range from $5,200 for nutrient inactivation to $258,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would be from $3,900 for nutrient inactivation to $193,100 for sediment covering.

Lake Beulah

Lake Beulah is an 834-acre lake located in the Town of East Troy in Walworth County. The lake drains through the Mukwonago River to the Fox River. Certain geomorphological characteristics of Lake Beulah are set forth in Table C-19, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-7 presents a graphic summary of the proposed year 2000

## Table C-18

## WATER QUALITY MANAGEMENT MEASURES FOR BENEDICT/TOMBEAU LAKE IN KENOSHA AND WALWORTH COUNTIES

| Alternative Plan Element Description | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 90 |
| Livestock Waste Control | $ 38,500 | $ 3,300 | $ 28,800 | $ 38,700 | $ 67,500 | $ 1,800 | $ 2,500 | $ 4,300 | | |
| Rural Conservation Practices[b] | 30,200 | 7,800 | 22,400 | 94,800 | 117,200 | 1,400 | 6,000 | 7,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 600 | Minimal | 9,000 | 9,000 | Minimal | 600 | 600 | | |
| Total | 68,700 | 11,700 | 51,200 | 142,500 | 193,700 | 3,200 | 9,100 | 12,300 | | |
| Macrophyte Harvesting[c] | 18,600 | 2,600 | 13,900 | 41,000 | 54,900 | 900 | 2,600 | 3,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Nutrient Inactivation[d] | 5,200 to 12,900 | – | 3,900 to 9,600 | – | 3,900 to 9,600 | 200 to 600 | – | 200 to 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 258,000 | – | 193,100 | – | 193,100 | 12,300 | – | 12,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of septic tank systems is recommended to help improve the water quality of Benedict/Tombeau Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Benedict/Tombeau Lake drainage basin include a capital cost over the period of 1975-2000 of $292,500, an average annual operation and maintenance cost of $4,000, and a total 50-year present worth cost of $303.100.*

[b] *Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 20 acres of Benedict/Tombeau Lake subject to excessive macrophyte growth.*

[d] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The cost of sediment covering may vary widely depending on such factors as lake size and depth, type of bottom substrate and amount of fill required.*

*Source: SEWRPC*

land cover in the lake watershed. An insignificant portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975 an estimated 468 privately owned onsite sewage disposal systems—280 of which were located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-20, all sources combined contribute about 3,600 pounds of phosphorus annually to Lake Beulah. The major direct sources of phosphorus in the lake watershed are livestock operations and runoff from rural lands. Also, as indicated in Table C-20, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Total phosphorus loads will be reduced slightly as a result of sewering some areas near East Troy and Mukwonago now served by septic tank systems. Phosphorus loadings from livestock operations and rural land runoff may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.05 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Beulah which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

## Table C-19

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE BEULAH

| Characteristic | Description |
|---|---|
| Surface Area | 834 acres |
| Direct Tributary Drainage Area | 5,283 acres |
| Shoreline | 1.53 miles |
| Depth | |
| Maximum | 58 feet |
| Mean | 17 feet |
| Volume | 14,279 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,600 persons |
| General Existing Water Quality Conditions: | Localized excessive macrophyte growth; hypolimnion occasionally devoid of oxygen |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.42 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-20

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE BEULAH: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 908 | 257 | 7.1 | 908 | 257 | 7.1 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 280 | 811 | 22.4 | 271 | 784 | 21.8 |
| Rural Land Cover (acres) | 4,375 | 1,084 | 29.9 | 4,375 | 1,084 | 30.1 |
| Livestock Operations (animal units) | 160 | 1,056 | 29.1 | 160 | 1,056 | 29.4 |
| Atmospheric Contribution (acres of receiving surface water) | 834 | 417 | 11.5 | 834 | 417 | 11.6 |
| Total | – | 3,625 | 100.0 | – | 3,598 | 100.0 |

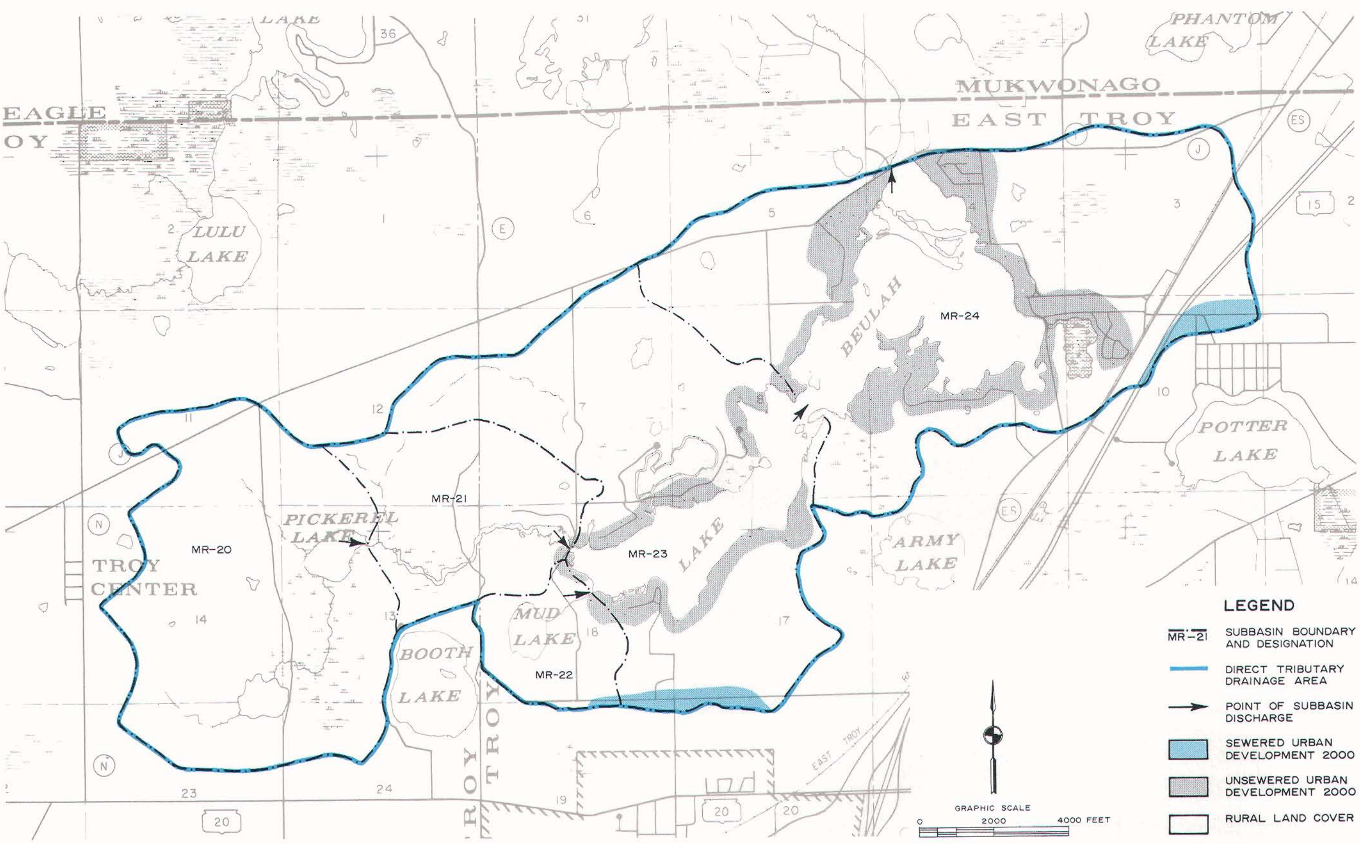
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Map C-7

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE BEULAH: 2000




Lake Beulah has a direct tributary drainage area of about 5,283 acres. About 4,375 acres, or 83 percent of the drainage area, are planned to be in rural land cover, and 908 acres, or 17 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed is expected to be converted to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, sources along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made, and a set of recommended measures was identified. These measures are set forth in Table C-21, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include the following: improved septic tank management; minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices; and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been previously deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures as set forth in Table C-21 may include sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lake Beulah requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint pollution control measures to control the nutrient inputs to Lake Beulah would entail a total capital cost of about $15,000, and an average annual operation and maintenance cost of about $10,400. The total 50-year present worth cost

**Table C-21**

**WATER QUALITY MANAGEMENT MEASURES FOR LAKE BEULAH IN WALWORTH COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Alternative Plan Element Description | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Septic Tank System Management[a] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 60 |
| Livestock Waste Control | $ 14,100 | $ 1,200 | $ 10,500 | $ 14,100 | $ 24,600 | $ 1,700 | $ 900 | 1,600 | | |
| Minimum Rural Conservation Practices | 900 | 7,700 | 700 | 93,400 | 94,100 | 100 | 400 | 500 | | |
| Low Cost Urban Land Management Practices | — | 1,500 | — | 22,200 | 22,200 | — | 1,400 | 1,400 | | |
| Total Diffuse Source Control | 15,000 | 10,400 | 11,200 | 129,700 | 140,900 | 800 | 2,700 | 3,500 | | |
| Macrophyte Harvesting[b] | 55,900 | 7,800 | 41,800 | 122,900 | 164,700 | 2,600 | 7,800 | 10,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 56,700 | 1,400 | 42,400 | 22,100 | 64,500 | 2,700 | 1,400 | 4,100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 28,400 to 83,900 | — | 21,200 to 62,300 | | 21,200 to 62,300 | 1,300 to 4,000 | | 1,300 to 4,000 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 1,668,000 | — | 1,246,500 | | 1,246,500 | 79,100 | | 79,100 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Beulah. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Beulah drainage basin include a capital cost over the period of 1975-2000 of $1,260,000, an average annual operation and maintenance cost of $16,800, and a total 50-year present worth cost of $1,286,700.*

[b] *Cost estimated to harvest macrophytes from the 60 acres of Lake Beulah subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The cost for nutrient inactivation is for treating only the hypolimnetic area with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs for sediment covering vary widely depending on such factors as size and depth of lake, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $140,900 with an equivalent annual cost of $3,500. If in addition, rehabilitation techniques are found necessary the capital cost of these alternatives would range from $28,400 for nutrient inactivation to $1,668,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $21,200 for nutrient activation to $1,246,500 for sediment covering.

Big Muskego Lake

Big Muskego Lake is a 2,073-acre lake located totally within the City of Muskego in Waukesha County. The lake drains through the Wind Lake Drainage Canal to the Fox River. Certain geomorphological characteristics of Big Muskego Lake are set forth in Table C-22 together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. As of 1975, an estimated 693 privately owned onsite sewage disposal systems—342 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. Map C-8 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-8, a portion of the year 2000 urban land uses in the tributary watershed area will be served by sanitary sewers.

As indicated in Table C-23, all direct sources combined contribute about 40,000 pounds of phosphorus annually to Big Muskego Lake. The major sources of phosphorus in the lake watershed are the City of Muskego sewage treatment facility, livestock operations, and rural land runoff. Discharge from Little Muskego Lake contributes an estimated additional 4,800 pounds of phosphorus to Big Muskego Lake. Also, as indicated in Table C-23, urban land uses in the watershed are expected to increase by about 200 percent under planned year 2000 land cover conditions, with annual direct total phosphorus loadings to the lake expected to be reduced to about 26,800 pounds, as a result of changing land use patterns, the extension of sanitary sewer services, and the abandonment of the City of Muskego sewage treatment facility. By 2000, loadings from Little Muskego Lake are expected to be reduced to 1,000 pounds of phosphorus annually. Loadings from livestock operations and rural runoff are expected to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.21 milligram per liter (mg/l) and 0.13 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for recreational use and a warmwater fishery and aquatic life classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Big Muskego Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Table C-22

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BIG MUSKEGO LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 2,073 acres |
| Direct Tributary Drainage Area | 12,150 acres |
| Shoreline | 26.13 miles |
| Depth | |
| Maximum | 4.0 feet |
| Mean | 2.5 feet |
| Volume | 5,469 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 3,411 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; fish winterkill; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.92 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-23

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BIG MUSKEGO LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,234 | 765 | 1.9 | 3,812 | 1,744 | 6.5 |
| Land under Development—Construction Activities (acres) | 96 | 4,300 | 10.7 | 96 | 4,300 | 16.1 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 342 | 990 | 2.5 | 193 | 560 | 2.1 |
| Rural Land Cover (acres) | 10,820 | 11,361 | 28.1 | 8,242 | 8,615 | 32.2 |
| Livestock Operations (animal units) | 1,585 | 10,461 | 25.9 | 1,585 | 10,461 | 39.0 |
| Atmospheric Contribution (acres of receiving surface water) | 2,177 | 1,089 | 2.7 | 2,177 | 1,089 | 4.1 |
| Point Sources (cfs) | 0.89 | 11,400 | 28.2 | – | – | – |
| Total | – | 40,366[c] | 100.0 | – | 26,769[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

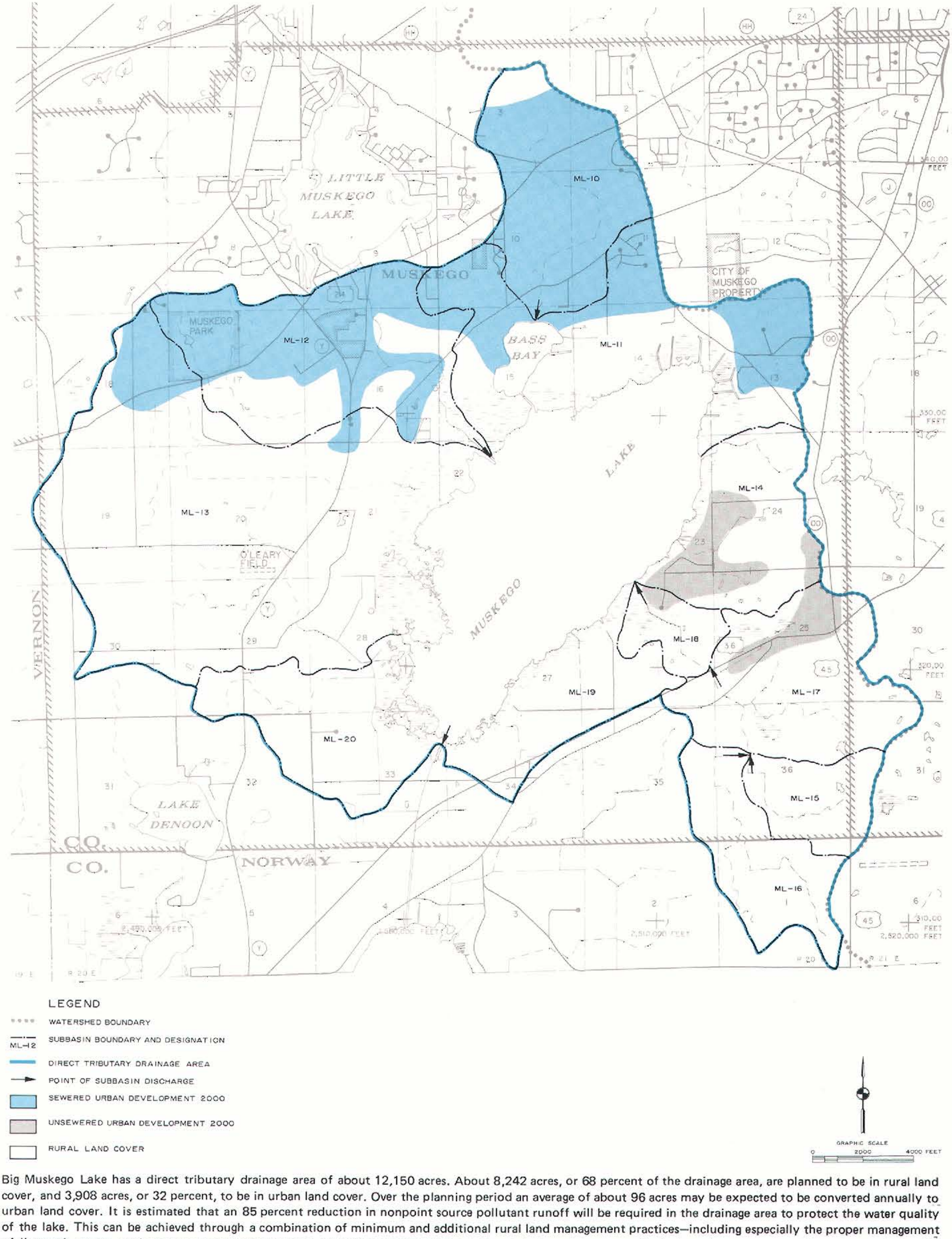
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 4,780 pounds per year, nor the year 2000 anticipated phosphorus load of 1000 pounds per year contributed from the outflow of Little Muskego Lake.*

*Source: SEWRPC.*

**Map C-8**

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF MUSKEGO LAKE: 2000**




Big Muskego Lake has a direct tributary drainage area of about 12,150 acres. About 8,242 acres, or 68 percent of the drainage area, are planned to be in rural land cover, and 3,908 acres, or 32 percent, to be in urban land cover. Over the planning period an average of about 96 acres may be expected to be converted annually to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and urban management practices—including construction erosion controls and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-24, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost effective way to substantially reduce nonpoint source phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service to portions of the northern lake watershed area, improved septic tank management, measures to reduce pollutant runoff from rural lands by 75 percent, additional measures to reduce pollutant runoff from urban lands by 50 percent, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source of excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned point and diffuse source controls. Alternative restoration mea-

### Table C-24

### WATER QUALITY MANAGEMENT MEASURES FOR BIG MUSKEGO LAKE IN WAUKESHA COUNTY

| Alternative Plan Element Description | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | — | — | — | — | — | — | — | — | Protect public health and drinking water supplies; reduce nutrient concentrations | — |
| Septic Tank System Management[c] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 139,500 | $ 11,900 | $ 104,300 | $ 140,000 | $ 244,300 | $ 16,600 | $ 8,900 | $ 25,500 | | |
| Rural Conservation Practices[d] | 1,110,000 | 144,600 | 934,600 | 727,500 | 1,662,100 | 59,200 | 46,200 | 105,400 | | |
| Construction Erosion Control Practices[e] | 4,415,000 | 38,200 | 3,313,700 | 602,500 | 3,916,200 | 210,200 | 38,200 | 248,400 | | |
| Low-Cost Urban Land Management Practices | Minimal | 4,300 | Minimal | 62,400 | 62,400 | Minimal | 4,000 | 4,000 | | |
| Additional Urban Land Management Practices[f] | 88,400 | 45,300 | 62,900 | 531,000 | 593,900 | 4,000 | 33,600 | 37,600 | | 85[j] |
| Total Diffuse Source Control | 5,752,900 | 244,300 | 4,415,500 | 2,063,400 | 6,478,900 | 280,000 | 130,900 | 420,900 | | |
| Sediment Covering[g,i] | 4,354,000 | — | 3,253,700 | — | 3,253,700 | 206,400 | — | 206,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Limited Dredging[h,i] | 4,000,000 | — | 2,989,200 | — | 2,989,200 | 189,600 | — | 189,600 | Deepen lake; reduce macrophyte growth | No additional reduction |

*a The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

*b Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Milwaukee Metropolitan subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Big Muskego Lake drainage basin include a capital cost over the period of 1975-2000 of $928,000, an average annual operation and maintenance cost of $9,500, and a total 50-year present worth cost of $669,800.*

*c The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Big Muskego Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Big Muskego Lake drainage basin include a capital cost over the period of 1975-2000 of $868,500, an average annual operation and maintenance cost of $16,600, and a total 50-year present worth cost of $1,052,800.*

*d Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads.*

*e Cost estimated to control erosion from the estimated 81.56 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*f Urban land management practices necessary to achieve a 50 percent reduction in urban diffuse source pollutant loads.*

*g Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*h Cost estimated to dredge to an average depth of 15 feet.*

*i The cost for sediment covering and dredging may vary depending on such factors as lake size and depth, type of bottom substrate, and amount and type of material to be filled or dredged.*

*j The reduction in the direct phosphorus load to Big Muskego Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Little Muskego Lake if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element for Little Muskego Lake must be implemented if Big Muskego Lake is to meet the water quality criteria for recreation and warmwater fishery.*

*Source: SEWRPC.*

sures, as set forth in Table C-24, may include sediment covering. Limited dredging to deepen portions of the lake and remove nutrient rich sediments could also improve lake water quality. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Big Muskego Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Big Muskego Lake would entail a total capital cost of about $5,753,000, and an average annual operation and maintenance cost of about $244,300. The total 50-year present worth cost of these nonpoint source control measures is $6,478,900, with an equivalent annual cost of $420,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,000,000 for limited dredging to $4,354,000 for sediment covering. The total present worth cost of these lake rehabilitation techniques would range from $2,989,200 for limited dredging to $3,253,700 for sediment covering.

Table C-25

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BOHNER LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 135 acres |
| Direct Tributary Drainage Area | 1,098 acres |
| Shoreline | 1.9 miles |
| Depth | |
| Maximum | 30 feet |
| Mean | 9.2 feet |
| Volume | 1,243 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 832 persons |
| General Existing Water Quality Conditions: | Although recent water quality data are unavailable for Bohner Lake, it is expected that the lake continues to experience excessive algae and weed growth problems |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.38 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

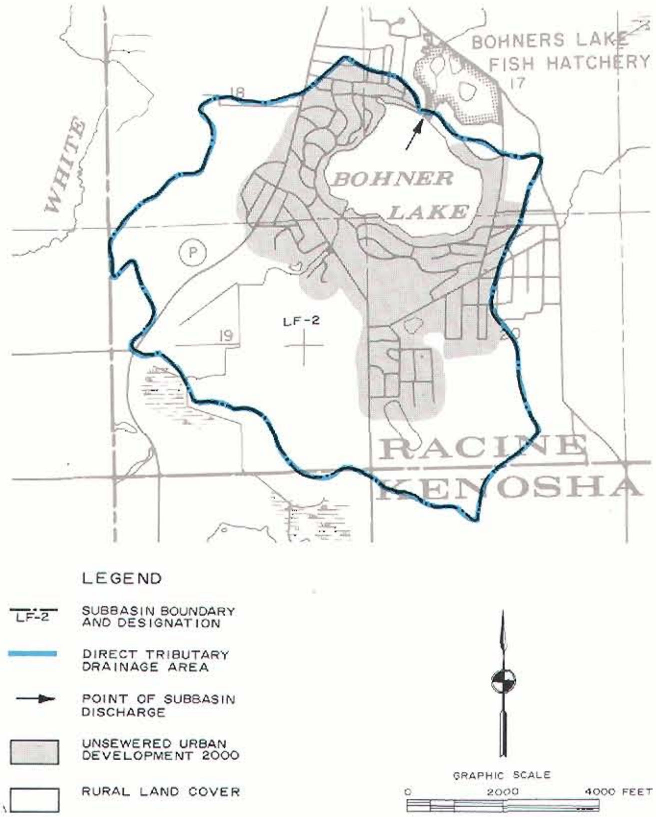
*Source: SEWRPC.*

<u>Bohner Lake</u>

Bohner Lake is a 135-acre lake located in the Town of Burlington in Racine County. The lake drains to the Fox River via Spring Brook. Certain geomorphological characteristics of Bohner Lake are set forth in Table C-25, together with the approximate 1975 populaton of the direct tributary watershed and a brief description of lake water quality conditions. Map C-9 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-9, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers. As of 1975, an estimated 542 privately owned onsite sewage disposal systems—125 of which were located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

Map C-9

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY AREA OF BOHNER LAKE: 2000




Bohner Lake has a direct tributary drainage area of about 1,098 acres. About 717 acres, or 65 percent of the drainage area, are planned to be in rural land cover, and 381 acres, or 35 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 70 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

As indicated in Table C-26, all direct sources combined contribute about 1,060 pounds of phosphorus annually to Bohner Lake. The major sources of phosphorus in the livestock operations. Sources which drain to Dyer Lake are not included since discharge through Dyer Lake is assumed to be negligible. Also as indicated in Table C-26, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from septic tank systems and livestock runoff may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.06 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Bohner Lake which exceed the phosphorus level estimated to be necessary to maintain water quality suitable for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-27, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include the following: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures, as set forth in Table C-27, may include dredging, sediment covering, nutrient inactivation, and hypolimnetic aeration. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Bohner Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient input to Bohner Lake would entail a total capital cost of about $6,300, and an average annual operation and maintenance cost of about $2,400. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $35,500, with an equivalent annual cost of $2,400. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $3,100 for nutrient inactivation and $1,306,500 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $2,300 for nutrient inactivation to $976,300 for dredging.

**Table C-26**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BOHNER LAKE: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 381 | 62 | 5.9 | 381 | 62 | 5.9 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 125 | 362 | 34.1 | 125 | 362 | 34.1 |
| Rural Land Cover (acres) | 717 | 106 | 10.1 | 717 | 106 | 10.1 |
| Livestock Operations (animal units) | 70 | 462 | 43.5 | 70 | 462 | 43.5 |
| Atmospheric Contribution (acres of receiving surface water) | 135 | 68 | 6.4 | 135 | 68 | 6.4 |
| Total | – | 1,060[c] | 100.0 | – | 1,060[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the estimated upstream total phosphorus load from Dyer Lake which is allowed to be negligible under both 1975 and anticipated year 2000 conditions.*

*Source: SEWRPC.*

Table C-27

## WATER QUALITY MANAGEMENT MEASURES FOR BOHNER LAKE IN RACINE COUNTY

| Alternative Plan Element Description | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 70 |
| Livestock Waste Control | $ 6,200 | $ 500 | $ 4,600 | $ 6,200 | $ 10,800 | $ 300 | $ 400 | $ 700 | | |
| Minimum Rural Conservation Practices | 100 | 1,300 | 100 | 15,300 | 15,400 | > 100 | 1,000 | 1,100 | | |
| Low Cost Urban Land Management Practices | Minimal | 600 | Minimal | 9,300 | 9,300 | Minimal | 600 | 600 | | |
| Total Diffuse Source Control | 6,300 | 2,400 | 4,700 | 30,800 | 35,500 | 400 | 2,000 | 2,400 | | |
| Macrophyte Harvesting[b] | 46,600 | 6,500 | 34,800 | 102,500 | 137,300 | 2,200 | 6,500 | 8,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 6,200 | 200 | 4,600 | 3,200 | 7,800 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 3,100 to 13,500 | – | 2,300 to 10,100 | – | 2,300 to 10,100 | 100 to 600 | – | 100 to 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body. | No additional reduction |
| Sediment Covering[e,g] | 270,000 | – | 201,800 | – | 201,800 | 12,800 | – | 12,800 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f] | 1,306,500 | – | 976,300 | – | 976,300 | 61,900 | – | 61,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

*[a] The proper maintenance and replacement of septic tank systems is recommended to help improve the water quality of Bohner Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Bohner Lake drainage basin include a capital cost over the period of 1975-2000 of $562,500, an average annual operation and maintenance cost of $17,500, and a total 50-year present worth cost of $906,500.*

*[b] Cost estimated to harvest macrophytes from the 50 acres of Bohner Lake subject to excessive macrophyte growth.*

*[c] Cost estimated to aerate the entire hypolimnion of the lake.*

*[d] The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

*[e] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[f] Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 9 feet.*

*[g] The costs for dredging and sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

### Booth Lake

Booth Lake is a 113-acre landlocked lake located in the Town of Troy in Walworth County. Certain geomorphological characteristics of Booth Lake are set forth in Table C-28, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-10 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-10 none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers. As of 1975, an estimated 70 privately owned onsite sewage disposal systems—17 located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-29, all sources combined contribute about 127 pounds of phosphorus annually to Booth Lake. The major sources of phosphorus in the lake watershed are atmospheric loadings and contributions from septic tanks. Also as indicated in Table C-29, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from atmospheric loadings and septic tank loadings may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus

Table C-28

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BOOTH LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 113 acres |
| Direct Tributary Drainage Area | 146 acres |
| Shoreline | 1.79 miles |
| Depth | |
| Maximum | 24 feet |
| Mean | 12.2 feet |
| Volume | 1,376 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 240 persons |
| General Existing Water Quality Conditions: | Low nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.42 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-29

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BOOTH LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 95 | 14 | 11.0 | 95 | 14 | 11.0 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 17 | 49 | 38.6 | 17 | 49 | 38.6 |
| Rural Land Cover (acres) | 51 | 7 | 5.5 | 51 | 7 | 5.5 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 113 | 57 | 44.9 | 113 | 57 | 44.9 |
| Total | – | 127 | 100.0 | – | 127 | 100.0 |

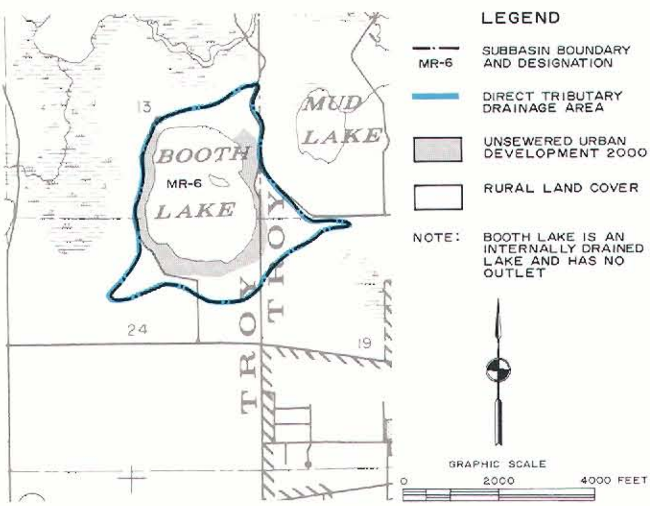
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-10

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BOOTH LAKE PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF BOOTH LAKE: 2000




Booth Lake has a direct tributary drainage area of about 146 acres. About 51 acres, or 35 percent of the drainage area, are planned to be in rural land cover, and 95 acres, or 65 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

loadings and lake and drainage basin characteristics, is 0.01 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Booth Lake which are below the recommended level for recreational use and for the maintenance of a warmwater fishery. Although existing and 2000 year water use objectives are expected to be met, it is critical that continued efforts be made to protect the existing and future lake water quality conditions.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-30, along with the associated costs and anticipated effectiveness. Measures to control phosphorus

Table C-30

## WATER QUALITY MANAGEMENT MEASURES FOR BOOTH LAKE IN WALWORTH COUNTY

| Alternative Plan Element Description | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices[b] | $ <100 | $ <100 | $ <100 | $ 1,100 | $ 1,200 | $ <100 | $ <100 | $ 200 | | |
| Low Cost Urban Land Management Practices | Minimal | 200 | Minimal | 2,300 | 2,300 | Minimal | 100 | 100 | | |
| Total Diffuse Source Control | 100 | 300 | 100 | 3,400 | 3,500 | 100 | 200 | 300 | | 40 |
| Nutrient Inactivation[c] | 2,000 to 11,300 | – | 1,500 to 8,400 | – | 1,500 to 8,400 | 100 to 500 | – | 100 to 500 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[b,d] | 226,000 | – | 168,900 | – | 168,900 | 10,700 | – | 10,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Booth Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Booth Lake drainage basin include a capital cost over the period of 1975-2000 of $76,500, an average annual operation and maintenance cost of $2,300, and a total 50-year present worth cost of $119,500.*

[b] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[c] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[d] *The costs of sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

input include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in selected areas and may release nutrients to the water body, resulting in poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures as set forth in Table C-30 may include sediment covering, or nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term protection and maintenance of water quality in Booth Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Booth Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $300. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $3,500 with an equivalent annual cost of $300. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $2,000 for nutrient inactivation to $226,000 for sediment covering. The total present worth costs of these rehabilitation techniques would range from $1,500 for nutrient inactivation to $168,900 for sediment covering.

Browns Lake

Browns Lake is a 396-acre lake located in the Town of Rochester in Racine County. The lake drains to the Fox River via Hoosier Creek. Certain geomorphological characteristics of Browns Lake are set forth in Table C-31, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[1] Map C-11 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-11, essentially all of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, only two privately owned onsite sewage disposal systems were in operation in the lake watershed area. Prior to 1973 when sanitary sewer service was provided to urban development in the lake watershed, malfunctioning septic systems were a significant source of water pollutants to Browns Lake.

[1] *Report on Browns Lake, Racine County; National Eutrophication Survey, U.S. Environmental Protection Agency, 1972.*

Table C-31

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BROWNS LAKE

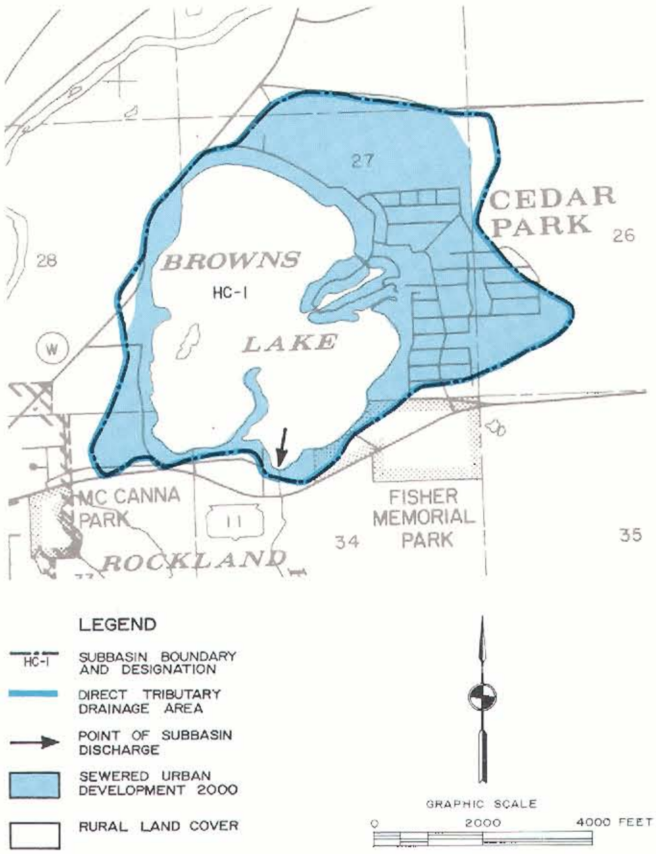
| Characteristic | Description |
|---|---|
| Surface Area | 396 acres |
| Direct Tributary Drainage Area | 526 acres |
| Shoreline | 5.7 miles |
| Depth | |
| Maximum | 44 feet |
| Mean | 8 feet |
| Volume | 3,135 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,547 persons |
| General Existing Water Quality Conditions: | Anaerobic conditions in hypolimnion during summer stratification; blue-green algae blooms occasionally occur; dense macrophyte growth; low to moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.38 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-11

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF BROWNS LAKE: 2000




Browns Lake has a direct tributary drainage area of about 526 acres. About 136 acres, or 26 percent of the drainage area, are planned to be in rural land cover, and 390 acres, or 74 percent, to be in urban land cover. Over the planning period an average of about two acres may be expected to be converted annually to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural practices—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the drainage area.

*Source: SEWRPC.*

Table C-32

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BROWNS LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 336 | 87 | 21.1 | 388 | 155 | 33.3 |
| Land under Development—Construction Activities (acres) | 2 | 94 | 22.9 | 2 | 94 | 20.3 |
| Onsite Sewage Disposal Septic Tank Systems[b] | < 5 | 6 | 1.4 | – | – | – |
| Rural Land Cover (acres) | 188 | 27 | 6.6 | 136 | 19 | 4.0 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 396 | 198 | 48.0 | 396 | 198 | 42.4 |
| Total | – | 412 | 100.0 | – | 466 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

As indicated in Table C-32, all sources combined contribute about 412 pounds of phosphorus annually to Browns Lake. The major sources of phosphorus in the lake watershed are atmospheric sources, construction activities, and residential land runoff. Also, as indicated in Table C-32, urban land uses in the watershed are expected to increase by approximately 15 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings expected to increase to about 466 pounds, unless reduced by nonpoint source controls. Phosphorus loadings from atmospheric sources, construction activities, and residential land uses, however, are expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The sewer service area is proposed to be extended under year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.013 milligram per liter (mg/l) and 0.015 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. While Browns Lake has historically exhibited excessive nutrient concentrations, water quality conditions in the lake are expected to improve significantly in the future as a result of the installation of sanitary sewers in 1973. Total phosphorus measurements taken in 1974 and 1975 averaged about 0.10 mg/l, as compared to values which averaged 0.26 mg/l total phosphorus measured prior to, or immediately following the provision of sanitary sewer service. Existing and planned year 2000 pollutant loadings to Browns Lake do not exceed the level estimated to be necessary to maintain a water quality suitable for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-33, along with the associated costs and anticipated effectiveness. Other needed measures include: the extension of sanitary sewer service, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

### Table C-33

### WATER QUALITY MANAGEMENT MEASURES FOR BROWNS LAKE IN RACINE COUNTY

| Alternative Plan Element Description | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | — | — | — | — | — | — | — | — | Protect public health and drinking water supplies; reduce nutrient concentrations | — |
| Minimum Rural Conservation Practices | $ 100 | $ 300 | $ 100 | $ 3,400 | $ 3,500 | $ 100 | $ 200 | $ 300 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 25 |
| Construction Erosion Control Practices[c] | 92,400 | 800 | 69,400 | 12,600 | 82,000 | 4,400 | 800 | 5,200 | | |
| Low Cost Urban Land Management Practices | — | 600 | — | 8,800 | 8,800 | — | 600 | 600 | | |
| Total Diffuse Source Control | 92,500 | 1,700 | 69,500 | 24,800 | 94,300 | 4,500 | 1,600 | 6,100 | | |
| Macrophyte Harvesting[d] | 83,900 | 11,700 | 62,700 | 184,400 | 247,100 | 4,000 | 11,700 | 15,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration | 17,400 | 400 | 13,000 | 6,300 | 19,300 | 800 | 400 | 1,200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[e] | 8,700 to 39,600 | — | 6,500 to 29,600 | — | 6,500 to 29,600 | 400 to 1,900 | — | 400 to 1,900 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,h] | 790,200 | — | 590,200 | — | 590,200 | 37,400 | — | 34,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 3,896,400 | — | 2,911,800 | — | 2,911,800 | 184,700 | — | 184,700 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Browns Lake drainage basin include a capital cost over the period of 1975-2000 of $656,000, an average annual operation and maintenance cost of $18,100, and a total 50-year present worth cost of $653,200.*

[c] *Cost estimated to control erosion from the estimated two acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *Cost estimated to harvest macrophytes from the 90 acres of Browns Lake subject to excessive macrophyte growth.*

[e] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 8.9 feet.*

[h] *The cost of dredging and sediment covering may vary depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

Prior to the provision of sanitary sewer service to the lake watershed, Browns Lake was in an advanced state of eutrophication. Therefore, extensive amounts of nutrient-rich sediments have been deposited on the lake bottom. These sediments will probably continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further study, the application of lake restoration or rehabilitation procedures should be considered. Alternative restoration measures as set forth in Table C-33 would include dredging, hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in more detailed preliminary engineering studies. Additional management measures, such as weed harvesting, may be used to control macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of Browns Lake requires that the recommended level of nutrient reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient input to Browns Lake would entail a total capital cost of about $92,500, and an average annual operation and maintenance cost of about $1,700. The total 50-year present worth cost of these nonpoint source control measures is $94,300, with an equivalent annual cost of $6,100. If, in addition, lake rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $8,700 for nutrient inactivation to $3.9 million for dredging. The total present worth costs of these lake rehabilitation techniques would range from $6,500 for nutrient inactivation to $2.9 million for dredging.

Camp Lake

Camp Lake is a 461-acre lake located in the Town of Salem in Kenosha County. The lake drains to Channel Lake in Illinois and eventually into the Fox River. Certain geomorphological characteristics of Camp Lake are set forth in Table C-34, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-12 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. Nearly all significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 480 privately owned onsite sewage disposal systems—427 of which were located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-35, all direct sources combined contribute about 2,220 pounds of phosphorus annually to Camp Lake. The major source of phosphorus in the lake watershed is septic tank systems. In addition, approximately 280 pounds of phosphorus are contributed annually from drainage from Center Lake. Also as indi-

Table C-34

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF CAMP LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 461 acres |
| Direct Tributary Drainage Area | 2,566 acres |
| Shoreline | 4.8 miles |
| Depth | |
| Maximum | 19 feet |
| Mean | 5 feet |
| Volume | 2,328 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,590 persons |
| General Existing Water Quality Conditions: | Occasional blue-green algae blooms; excessive macrophyte growth; frequent fish winterkill; high nutrient concentrations; anaerobic conditions in hypolimnion during summer |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-35

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO CAMP LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 516 | 147 | 6.6 | 814 | 284 | 14.2 |
| Land under Development—Construction Activities (acres) | – | – | – | 19 | 860 | 43.1 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 427 | 1,235 | 55.8 | 23 | 67 | 3.3 |
| Rural Land Cover (acres) | 2,050 | 313 | 14.1 | 1,733 | 264 | 13.2 |
| Livestock Operations (animal units) | 44 | 290 | 13.1 | 44 | 290 | 14.6 |
| Atmospheric Contribution (acres of receiving surface water) | 461 | 230 | 10.4 | 461 | 230 | 11.6 |
| Total | – | 2,217[c] | 100.0 | – | 1,995[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

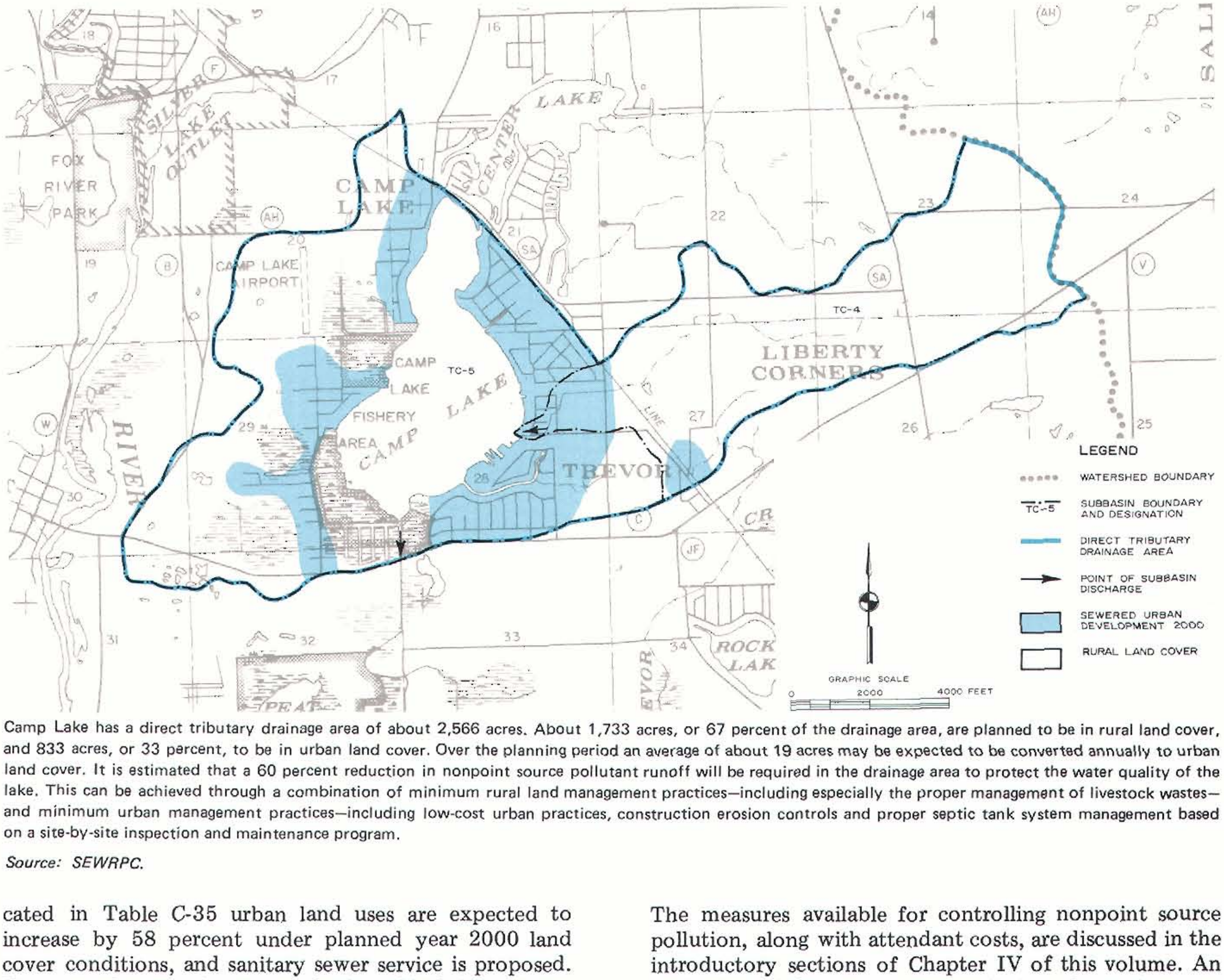
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated percentage annual phosphorus load of 280 pounds per year, or the year 2000 anticipated phosphorus load of 50 pounds per year contributed from the drainage of the Center Lake outlet.*

*Source: SEWRPC*

Map C-12

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF CAMP LAKE: 2000




Camp Lake has a direct tributary drainage area of about 2,566 acres. About 1,733 acres, or 67 percent of the drainage area, are planned to be in rural land cover, and 833 acres, or 33 percent, to be in urban land cover. Over the planning period an average of about 19 acres may be expected to be converted annually to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

cated in Table C-35 urban land uses are expected to increase by 58 percent under planned year 2000 land cover conditions, and sanitary sewer service is proposed. The annual total phosphorus load in 2000 from direct tributary sources is estimated to be about 2,000 pounds, with the Center Lake drainage phosphorus load decreasing to less than 50 pounds per year, assuming the recommended water quality plan for Center Lake is implemented.

The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.06 milligram per liter (mg/l) and 0.05 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Camp Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-36, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive mac-

## Table C-36

## WATER QUALITY MANAGEMENT MEASURES FOR CAMP LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | | | | | | | | | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 60 |
| Livestock Waste Control | $ 3,900 | $ 300 | $ 2,900 | $ 3,900 | $ 6,800 | $ 200 | $ 200 | $ 400 | | |
| Minimum Rural Conservation Practices | 400 | 3,300 | 300 | 40,400 | 40,700 | <100 | 2,600 | 2,700 | | |
| Construction Erosion Control Practices[d] | 877,800 | 7,600 | 658,800 | 119,800 | 778,600 | 41,800 | 7,600 | 49,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,100 | Minimal | 16,200 | 16,200 | Minimal | 1,000 | 1,000 | | |
| Total | 882,100 | 12,300 | 662,000 | 180,300 | 842,300 | 42,100 | 11,400 | 53,500 | | |
| Macrophyte Harvesting[e] | 279,600 | 39,000 | 208,900 | 614,700 | 823,600 | 13,300 | 39,000 | 52,300 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[f] | 40,000 | 1,000 | 29,900 | 15,800 | 45,700 | 1,900 | 1,000 | 2,900 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[g,i] | 922,000 | – | 689,000 | – | 689,000 | 43,700 | – | 43,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[h,i] | 7,436,000 | – | 5,556,900 | – | 5,556,900 | 352,500 | – | 352,500 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional areas. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Camp Lake drainage basin include a capital cost over the period of 1975-2000 of $2,836,000, an average annual operation and maintenance cost of $21,300, and a total 50-year present worth cost of $1,924,200.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Camp Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Camp Lake drainage basin include a capital cost over the period of 1975-2000 of $103,500, an average annual operation and maintenance cost of $1,800, and a total 50-year present worth cost of $120,300.*

[d] *Cost estimated to control erosion from the estimated 19 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 300 acres of Camp Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate 200 acres of the lake.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 5 feet.*

[i] *The cost for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate and the amount of material to be filled or dredged.*

*Source: SEWRPC.*

rophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above mentioned diffuse source controls. Alternative restoration measures as set forth in Table C-36 may include dredging aeration, and sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. Because of the shallowness of the lake, nutrient inactivation would probably not be effective. Other management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Camp Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Camp Lake would entail a total capital cost of about $882,100, and an average annual operation and maintenance cost of about $12,300. The total 50-year present worth cost of these nonpoint source control measures is $842,300, with an equivalent annual cost of $53,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would be $40,000 for aeration and $7,436,000 for dredging. The total present worth costs of lake rehabilitation techniques would be $45,700 for aeration and $5,556,900 for dredging.

Center Lake

Center Lake is a 129-acre lake located in the Town of Salem in Kenosha County. The lake drains to Camp Lake. Certain geomorphological characteristics of Center Lake are set forth in Table C-37, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-13 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-13, a large portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 492 privately owned onsite sewage disposal systems—124 of which were located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-38, all sources combined contribute about 2,668 pounds of phosphorus annually to Center Lake. The major sources of phosphorus in the lake watershed are septic tank systems and runoff from livestock operations. Also as indicated in Table C-38, the extent of urban land uses in the watershed is expected to increase by about 130 percent under planned year 2000 land cover conditions. Sanitary sewer service would be provided. The positive effects of sanitary sewer service on phosphorus loads are more than offset by the increased construction activities and urban land runoff in the year 2000, with the annual total phosphorus load in 2000 estimated to be about 3,431 pounds. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.16 milligram per liter (mg/l) and 0.20 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive squatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Center Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-39, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include the following: the provision of sanitary sewer service; improved septic tank management; measures to reduce pollutant runoff from rural lands by 75 percent; low-cost measures to reduce pollutant runoff from urban lands; and construction erosion control practices.

Table C-37

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF CENTER LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 129 acres |
| Direct Tributary Drainage Area | 2,243 acres |
| Shoreline | 6.5 miles |
| Depth | |
| Maximum | 28 feet |
| Mean | 8 feet |
| Volume | 1,136 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,629 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; low midsummer dissolved oxygen levels in hypolimnion; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-38

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO CENTER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 383 | 109 | 4.1 | 886 | 220 | 6.4 |
| Land under Development–Construction Activities (acres) | – | – | – | 23 | 1,035 | 30.2 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 124 | 359 | 13.5 | 20 | 58 | 1.7 |
| Rural Land Cover (acres) | 1,860 | 280 | 10.5 | 1,334 | 198 | 5.8 |
| Livestock Operations (animal units) | 281 | 1,856 | 69.5 | 281 | 1,856 | 54.0 |
| Atmospheric Contribution (acres of receiving surface water) | 129 | 64 | 2.4 | 129 | 64 | 1.9 |
| Total | – | 2,668 | 100.0 | – | 3,431 | 100.0 |

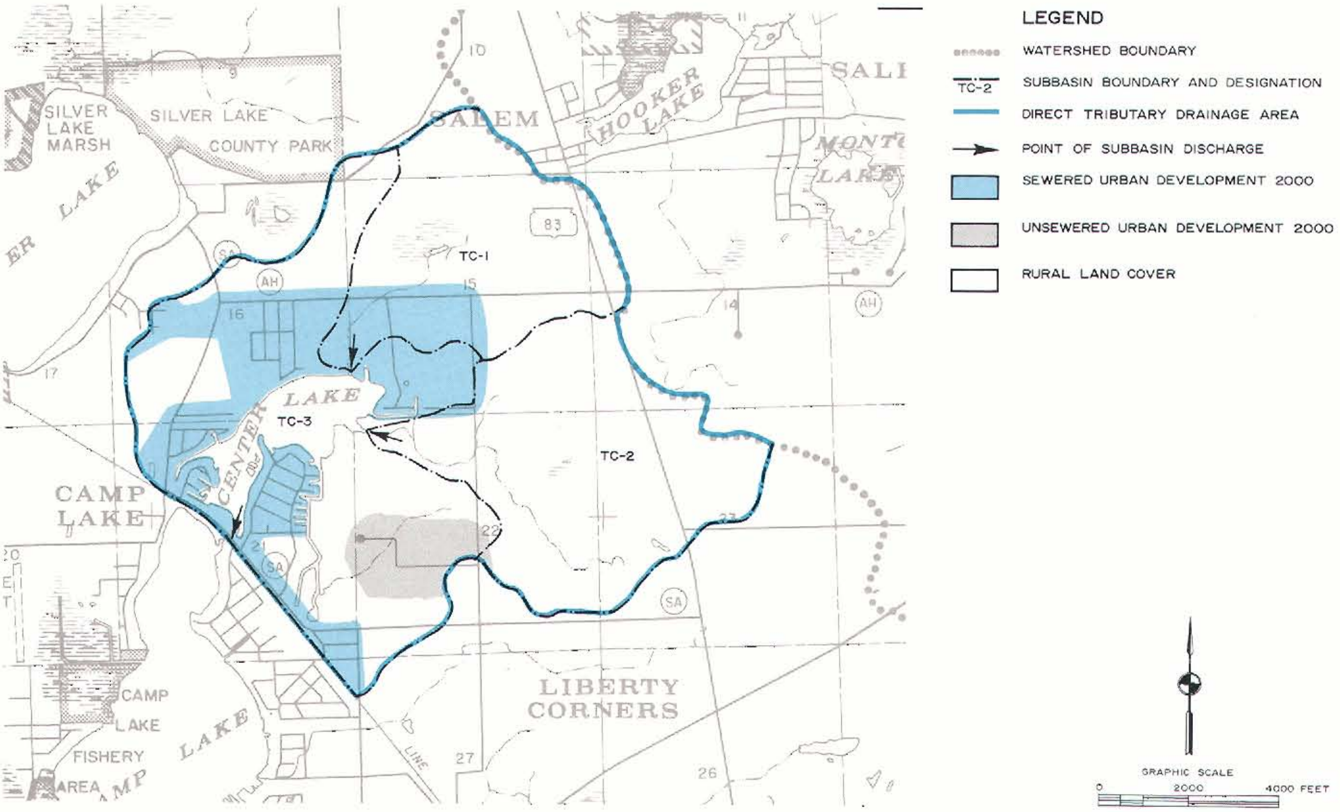
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-13

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF CENTER LAKE: 2000




Center Lake has a direct tributary drainage area of about 2,243 acres. About 1,334 acres, or 60 percent of the drainage area, are planned to be in rural land cover, and 909 acres, or 40 percent, to be in urban land cover. Over the planning period an average of about 23 acres may be expected to be converted annually to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned diffuse source controls. Alternative restoration measures as set forth in Table C-39 may include dredging, sediment covering, nutrient inactivation, and hypolimnetic aeration. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Center Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Center Lake would entail a total capital cost of about \$1,305,600, and an average annual operation and maintenance cost of about \$39,000. The total 50-year present worth cost of these nonpoint source control measures is \$1,329,200, with an equivalent annual cost of \$84,400. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from \$2,600 for nutrient inactivation to \$1,456,500 for dredging. The total present worth cost of these lake rehabilitation techniques would range from \$1,900 for nutrient inactivation to \$1,088,500 for dredging.

Table C-39

WATER QUALITY MANAGEMENT MEASURES FOR CENTER LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentration; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 90 |
| Livestock Waste Control | $ 53,000 | $ 4,000 | $ 39,600 | $ 47,000 | $ 86,600 | $ 2,500 | $ 3,000 | $ 5,500 | | |
| Rural Conservation Practice[d] | 190,000 | 24,800 | 160,000 | 124,600 | 284,600 | 10,200 | 7,900 | 18,100 | | |
| Construction Erosion Control Practice[e] | 1,062,600 | 9,200 | 797,500 | 145,000 | 942,500 | 50,600 | 9,200 | 59,800 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,000 | Minimal | 15,500 | 15,500 | Minimal | 1,000 | 1,000 | | |
| Total | 1,305,600 | 39,000 | 997,100 | 332,100 | 1,329,200 | 63,300 | 21,100 | 84,400 | | |
| Macrophyte Harvesting[f] | 23,300 | 3,300 | 17,400 | 51,200 | 69,400 | 1,100 | 3,300 | 4,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[g] | 5,200 | 100 | 3,900 | 2,000 | 5,900 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[h] | 2,600 to 12,900 | – | 1,900 to 9,600 | – | 1,900 to 9,600 | 100 to 600 | – | 100 to 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[i,k] | 258,000 | – | 192,800 | – | 192,800 | 12,200 | – | 12,200 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[j,k] | 1,456,500 | – | 1,088,500 | – | 1,088,500 | 69,100 | – | 69,100 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Center Lake drainage basin include a capital cost over the period of 1975-2000 of $4,348,000. an average annual operation and maintenance cost of $32,600, and a total 50-year present worth cost of $2,950,100.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Center Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Center Lake drainage basin include a capital cost over the period of 1975-2000 of $90,000, an average annual operation and maintenance cost of $1,900, and a total 50-year present worth cost of $114,400.*

[d] *Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads.*

[e] *Cost estimated to control erosion from the estimated 23 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[f] *Cost estimated to harvest macrophytes from the 25 acres of Center Lake subject to excessive macrophyte growth.*

[g] *Cost estimated to aerate the entire hypolimnion of the lake.*

[h] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[i] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[j] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 8 feet.*

[k] *The cost of dredging and sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

Lake Como

Lake Como is a 946-acre lake located in the Town of Geneva in Walworth County. The lake drains to Como Creek. Certain geomorphological characteristics of Lake Como are set forth in Table C-40, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[2] Map C-14 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-14, all significant year 2000 urban land areas in the tributary watershed area is proposed to be served by sanitary sewers. As of 1975, an estimated 574 privately owned onsite sewage disposal systems—221 of which were located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

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[2]*Report on Lake Como, Walworth County, National Eutrophication Survey, U.S. Environmental Protection Agency, 1972.*

Table C-40

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE COMO

| Characteristic | Description |
|---|---|
| Surface Area | 946 acres |
| Direct Tributary Drainage Area | 4,058 acres |
| Shoreline | 8.0 miles |
| Depth | |
| Maximum | 9 feet |
| Mean | 4.3 feet |
| Volume | 4,033 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,722 persons |
| General Existing Water Quality Conditions: | Dense algae growth; excessive macrophyte growth; frequent fish winterkill; high nutrient concentrations; severe turbidity during the summer months |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.00 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-41

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE COMO: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,047 | 326 | 13.7 | 1,047 | 326 | 18.2 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 221 | 640 | 26.9 | 17 | 49 | 2.7 |
| Rural Land Cover (acres) | 3,011 | 612 | 25.7 | 3,011 | 612 | 34.3 |
| Livestock Operations (animal units) | 50 | 330 | 13.9 | 50 | 330 | 18.4 |
| Atmospheric Contribution (acres of receiving surface water) | 946 | 473 | 19.8 | 946 | 473 | 26.4 |
| Total | – | 2,381 | 100.0 | – | 1,790 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

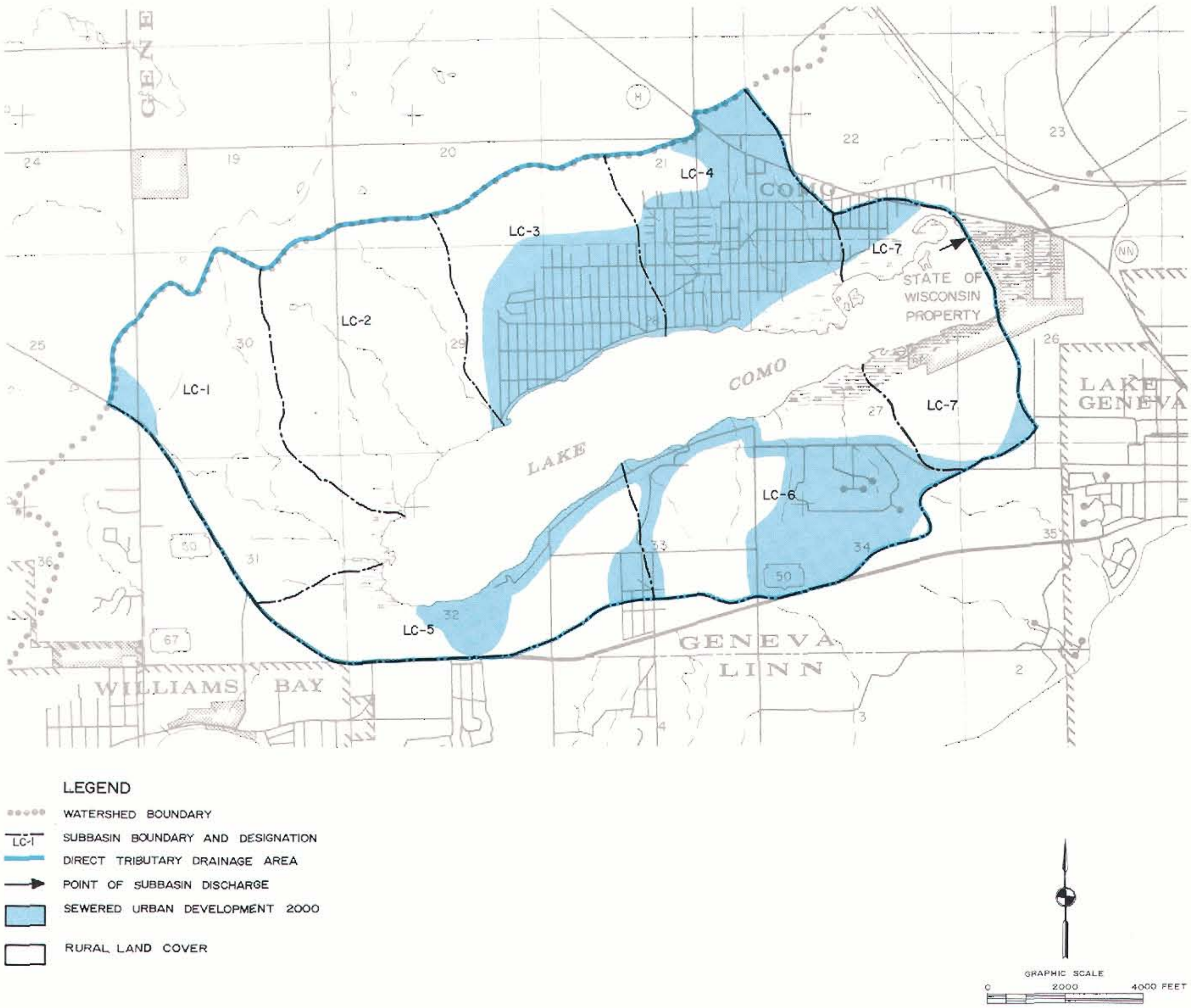
As indicated in Table C-41, all sources combined contribute about 2,381 pounds of phosphorus annually to Lake Como. The major source of phosphorus in the lake watershed is septic tank systems. Also as indicated in Table C-41, land uses in the watershed are not expected to change significantly under planned year 2000 land cover conditions, although annual total phosphorus loadings to the lake are expected to be reduced to about 1,790 pounds as a result of the recommended provision of sanitary sewer service. Loadings from direct atmospheric deposition of phosphorus on the lake surface and from rural land runoff are expected to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.03 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Como which exceed and meet respectively, the recommended level for recreational use and a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-42, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions are an effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. Since detailed studies of Como Lake conducted by the Wisconsin Department of Natural Resources indicated that organic sediments are constantly disturbed by wind and wave action and bulkhead activity, thereby increasing water turbidity, oxygen consumption, and nutrient release, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned point and diffuse source controls. Alternative restoration measures as set forth in Table C-42 may include sediment covering, dredging lake drawdown, and aeration. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth that may interfere with the

Map C-14

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE COMO: 2000




Lake Como has a direct tributary drainage area of about 4,058 acres. About 3,011 acres, or 74 percent of the drainage area, are planned to be in rural land cover, and 1,047 acres, or 26 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including management of the remaining septic tank systems based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lake Como requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Lake Como would entail a total capital cost of about $5,000, and an average annual operation and maintenance cost of about $7,400. The total 50-year present worth cost of these nonpoint source control measures is $98,000, with an equivalent annual cost of $6,200. If, in addition, rehabilitation techniques are implemented, the capital cost of these alternatives would range from $10,000 for aeration to $16.3 million for dredging. The total present worth costs of these lake rehabilitation techniques would be from $46,900 for aeration to $12.2 million for dredging.

Table C-42

WATER QUALITY MANAGEMENT MEASURES FOR LAKE COMO IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentration | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 4,400 | $ 400 | $ 3,300 | $ 4,400 | $ 7,700 | $ 200 | $ 300 | $ 500 | | |
| Minimum Rural Conservation Practices | 600 | 5,300 | 500 | 64,300 | 64,800 | 100 | 4,000 | 4,100 | | |
| Low Cost Urban Land Management Practices | – | 1,700 | – | 25,500 | 25,500 | – | 1,600 | 1,600 | | 30 |
| Total | 5,000 | 7,400 | 3,800 | 94,200 | 98,000 | 300 | 5,900 | 6,200 | | |
| Macrophyte Harvesting[d] | 227,400 | 31,700 | 169,900 | 500,000 | 669,900 | 10,800 | 31,700 | 42,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[e] | 10,000 | 2,500 | 7,500 | 39,400 | 46,900 | 500 | 2,500 | 3,000 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Lake Drawdown | Minimal | | — | Minimal | Minimal | — | Minimal | Minimal | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,h] | 1,892,000 | – | 1,413,900 | – | 1,413,900 | 89,700 | – | 89,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 16,327,100 | – | 12,201,000 | – | 12,201,000 | 774,000 | – | 774,000 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Lake Como drainage basin include a capital cost over the period of 1975-2000 of $2,104,000, an average annual operation and maintenance cost of $15,800, and a total 50-year present worth cost of $1,427,564.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Como. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Como drainage basin include a capital cost over the period of 1975-2000 of $76,500, an average annual operation and maintenance cost of $1,600, and a total 50-year present worth cost of $97,600.*

[d] *Cost estimated to harvest macrophytes from the 244 acres of Lake Como subject to excessive macrophyte growth.*

[e] *Cost estimated to aerate 50 acres of the lake.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 4.3 feet.*

[h] *The costs for dredging and sediment covering vary widely depending on lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

## Cross Lake

Cross Lake is an 87-acre lake located in the Town of Salem in Kenosha County. The lake drains to Trevor Creek. Certain geomorphological characteristics of Cross Lake are set forth in Table C-43, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-15 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-15 all of the year 2000 urban land in the tributary watershed area is proposed to be served by sanitary sewers. As of 1975, an estimated 120 privately owned onsite sewage disposal systems—all located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-44, all sources combined contribute about 490 pounds of phosphorus annually to Cross Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also as indicated in Table C-44, urban land uses in the watershed are expected to increase by about 30 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be reduced to about 293 pounds, as a result of the provision of sanitary sewer service. Loadings from the construction activities are expected to be the primary source of phosphorus to

Table C-43

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF CROSS LAKE

| Characteristic | Description |
|---|---|
| Surface Area . . . . . . . . . . . . | 87 acres |
| Direct Tributary Drainage Area . . . . . . . . . . . . . . . . . | 436 acres |
| Shoreline . . . . . . . . . . . . . . | 2.2 miles |
| Depth | |
| Maximum . . . . . . . . . . . | 35 feet |
| Mean . . . . . . . . . . . . . . . | 11.8 feet |
| Volume . . . . . . . . . . . . . . . | 1,029 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] . . . . . | 397 persons |
| General Existing Water Quality Conditions: | Low to moderate nutrient concentrations; excessive macrophyte growth or algae blooms have not been reported |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-44

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO CROSS LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) . . . . . . . . . . . . . | 195 | 63 | 12.9 | 254 | 78 | 26.6 |
| Land under Development—Construction Activities (acres) . . . . . . . . . . . . . . . . | – | – | – | 3 | 144 | 49.1 |
| Onsite Sewage Disposal Septic Tank Systems[b] . . . . . . . . . . . . . . . . . | 120 | 347 | 70.9 | – | – | |
| Rural Land Cover (acres) . . . . . . . . . . . . | 241 | 36 | 7.3 | 179 | 27 | 9.2 |
| Livestock Operations (animal units) . . . . . . | – | – | – | – | – | |
| Atmospheric Contribution (acres of receiving surface water) . . . . . . . . . . . . . | 87 | 44 | 8.9 | 87 | 44 | 15.1 |
| Total | – | 490 | 100.0 | – | 293 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

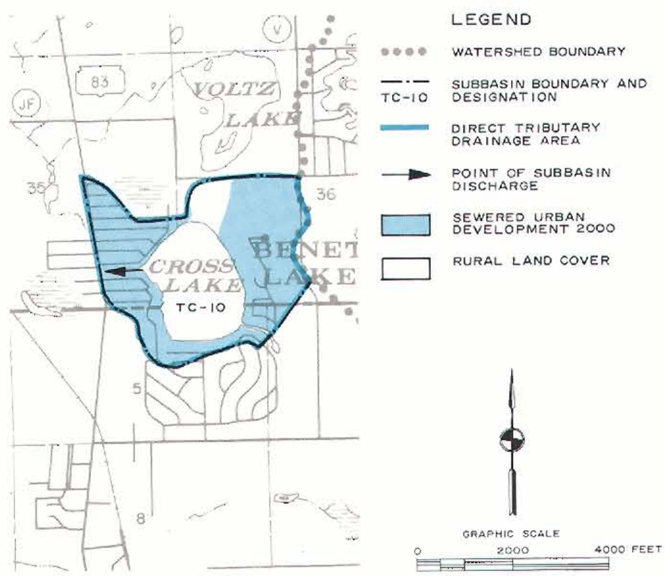
*Source: SEWRPC.*

the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.06 milligram per liter (mg/l) and 0.04 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Cross Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-45, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: the provision of sanitary sewer service, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

Map C-15

PLANNED LAKE COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF CROSS LAKE: 2000




Cross Lake has a direct tributary drainage area of about 436 acres. About 179 acres, or 41 percent of the drainage area, are planned to be in rural land cover, and 257 acres, or 59 percent, to be in urban land cover. Over the planning period an average of about three acres may be expected to be converted annually to urban land cover. It is estimated that 50 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and construction erosion controls.

*Source: SEWRPC.*

## Table C-45

## WATER QUALITY MANAGEMENT MEASURES FOR CROSS LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Minimum Rural Conservation Practices | $ <100 | $ 400 | $ 800 | $ 4,500 | $ 5,300 | $ <100 | $ 300 | $ 300 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 50 |
| Construction Erosion Control Practices[c] | 147,800 | 1,300 | 111,000 | 20,200 | 131,200 | 7,000 | 1,300 | 8,300 | | |
| Low Cost Urban Land Management Practices | Minimal | 400 | Minimal | 5,500 | 5,500 | Minimal | 300 | 300 | | |
| Total | 147,900 | 2,100 | 111,800 | 30,200 | 142,000 | 7,100 | 1,900 | 8,900 | | |
| Nutrient Inactivation[d] | 2,900 to 8,700 | – | 2,200 to 6,500 | – | 2,200 to 6,500 | 100 to 400 | – | 100 to 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 174,800 | – | 130,600 | – | 130,600 | 8,300 | – | 8,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Cross Lake drainage basin include a capital cost over the period of 1975-2000 of $628,000, an average annual operation and maintenance cost of $4,700, and a total 50-year present worth cost of $426,100.*

[c] *Cost estimated to control erosion from the estimated 3.2 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The cost of sediment covering vary widely depending on lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered in addition to the above-mentioned point and diffuse source controls. Alternative restoration measures as set forth in Table 132 may include sediment covering and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Cross Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Cross Lake would entail a total capital cost of about $147,900, and an average annual operation and maintenance cost of about $2,100. The total 50-year present worth cost of these nonpoint source control measures is $142,000, with an equivalent annual cost of $8,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $2,900 for nutrient inactivation to $174,800 for dredging. The total present worth costs of these lake rehabilitation techniques would be from $2,200 for nutrient activation and from $130,600 for dredging.

### Lake Denoon

Lake Denoon is a 162-acre lake located in the City of Muskego in Waukesha County. The lake drains to the Wind Lake Drainage Canal and then to the Fox River. Certain geomorphological characteristics of Lake Denoon are set forth in Table C-46 together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-16 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-16, all significant year 2000 urban land areas in the tributary watershed area are proposed to be served by sanitary sewers. As of 1975, an estimated 119 privately owned onsite sewage disposal systems—84 located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-47, all sources combined contribute about 3,900 pounds of phosphorus annually to Lake Denoon. The major source of phosphorus in the lake watershed is from livestock operations. Also, as indicated in Table C-47, urban land uses in the watershed are expected to increase by about 350 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to increase to about 4,500 pounds. Loadings from construction activities are expected to be significant source of phosphorus to the lake under anticipated year 2000 conditions, although livestock operations will still represent the primary source. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.27 milligram per liter (mg/l) and 0.31 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a recreational use and warmwater fishery and aquatic life classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Denoon which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Table C-46

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE DENOON

| Characteristic | Description |
|---|---|
| Surface Area | 162 acres |
| Direct Tributary Drainage Area | 1,013 acres |
| Shoreline | 2.40 miles |
| Depth | |
| Maximum | 55 feet |
| Mean | 18 feet |
| Volume | 2,940 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 466 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.92 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-47

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE DENOON: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 96 | 105 | 2.7 | 439 | 495 | 11.0 |
| Land under Development–Construction Activities (acres) | – | – | – | 17 | 770 | 17.1 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 84 | 243 | 6.2 | 4 | 12 | 0.3 |
| Rural Land Cover (acres) | 917 | 990 | 25.4 | 557 | 656 | 14.6 |
| Livestock Operations (animal units) | 376 | 2,482 | 63.6 | 376 | 2,482 | 55.2 |
| Atmospheric Contribution (acres of receiving surface water) | 162 | 81 | 2.1 | 162 | 81 | 1.8 |
| Total | – | 3,901 | 100.0 | – | 4,496 | 100.0 |

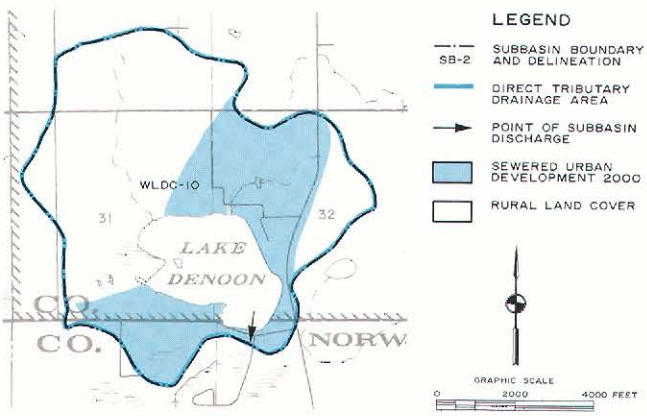
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-16

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE DENOON: 2000




Lake Denoon has a direct tributary drainage area of about 1,013 acres. About 557 acres, or 55 percent of the drainage area, are planned to be in rural land cover, and 456 acres, or 45 percent, to be in urban land cover. Over the planning period an average of about 17 acres may be expected to be converted annually to urban land cover. It is estimated that a 95 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and urban management practices—including low-cost and additional urban practices, construction erosion controls, proper septic tank system management based on a site-by-site inspection and maintenance program, and improved Department of Public Works maintenance programs.

*Source: SEWRPC.*

## Table C-48

## WATER QUALITY MANAGEMENT MEASURES FOR LAKE DENOON IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 95 |
| Livestock Waste Control | $ 33,100 | $ 2,800 | $ 24,700 | $ 33,200 | $ 57,900 | $ 1,600 | $ 2,100 | $ 3,700 | | |
| Rural Conservation Practices[d] | 87,700 | 11,400 | 73,800 | 57,500 | 131,300 | 4,700 | 3.600 | 8,300 | | |
| Construction Erosion Control Practices[e] | 785,400 | 6,800 | 589,500 | 107,200 | 696,700 | 37,400 | 6,800 | 44,200 | | |
| Low Cost Urban Land Management Practices | – | 400 | – | 6,500 | 6,500 | – | 400 | 400 | | |
| Additional Urban Land Management Practices[f] | 9,300 | 4,700 | 6,600 | 55,700 | 62,300 | 400 | 3,500 | 3,900 | | |
| Total | 915,500 | 26,100 | 694,600 | 260,100 | 954,700 | 44,100 | 16,400 | 60,500 | | |
| Macrophyte Harvesting[g] | 29,800 | 4,200 | 22,300 | 65,600 | 88,500 | 1,400 | 4,200 | 5,600 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[h] | 13,000 | 300 | 9,700 | 4,700 | 14,400 | 600 | 300 | 900 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[i] | 6,500 to 16,200 | – | 4,900 to 12,100 | – | 4,900 to 12,100 | 300 to 800 | – | 300 to 800 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[j,k] | 324,000 | – | 242,100 | – | 242,100 | 15,400 | – | 15,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Lake Denoon drainage basin include a capital cost over the period of 1975-2000 of $2,152,000, an average annual operation and maintenance cost of $16,100, and a total 50-year present worth cost of $1,460,100.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Denoon. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Denoon drainage basin include a capital cost over the period of 1975-2000 of $18,000, an average annual operation and maintenance cost of $300, and a total 50-year present worth cost of $17,700.*

[d] *Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads.*

[e] *Cost estimated to control erosion from the estimated 17 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[f] *Urban land management practices necessary to achieve a 50 percent reduction in urban diffuse source pollutant loads.*

[g] *Cost estimated to harvest macrophytes from the 32 acres of Lake Denoon subject to excessive macrophyte growth.*

[h] *Cost estimated to aerate the entire hypolimnion of the lake.*

[i] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[j] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[k] *The cost of sediment covering vary widely depending on lake size and depth, type of bottom material, and amount of material to be filled.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-48, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, measures to reduce pollutant runoff from rural lands by 75 percent, low-cost measures to reduce pollutant runoff from urban lands, measures to reduce pollutant runoff from urban lands by 50 percent, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above point and diffuse source controls. Alternative restoration measures as set forth in Table C-48 may include sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfer with the recreational use of the lake.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Lake Denoon would entail a total capital cost of about $915,500, and an average annual operation and maintenance cost of about $26,100. The total 50-year present worth cost of these nonpoint source control measures is $954,700 with an equivalent annual cost of $60,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $6,500 for nutrient inactivation to $324,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would be from $4,900 for nutrient inactivation and from $242,100 for sediment covering.

Dyer Lake

Dyer Lake is a 56-acre lake located in the Town of Wheatland in Kenosha County. The lake drains to Bohner Lake and eventually the Fox River. Certain geomorphological characteristics of Dyer Lake are set forth in Table C-49, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-17 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality management plan. The delineated tributary drainage area should be refined in a more detailed local lake study. Most of the surrounding lake shoreline is owned by the Boy Scouts of America and operated as a youth camp. Although very little low-density urban land exists in the watershed, about 14 septic systems serve rural residences and the Boy Scout recreational facilities. All septic systems, however, are located on suitable soils and, properly maintained, should not contribute a significant amount of pollutants to the lake.

As indicated in Table C-50, all sources combined contribute about 684 pounds of phosphorus annually to Dyer Lake. The major sources of phosphorus in the lake watershed are rural land runoff and runoff from livestock operations. Also, as indicated in Table C-50, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from rural land runoff and livestock operations may be expected to con-

Table C-49

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF DYER LAKE

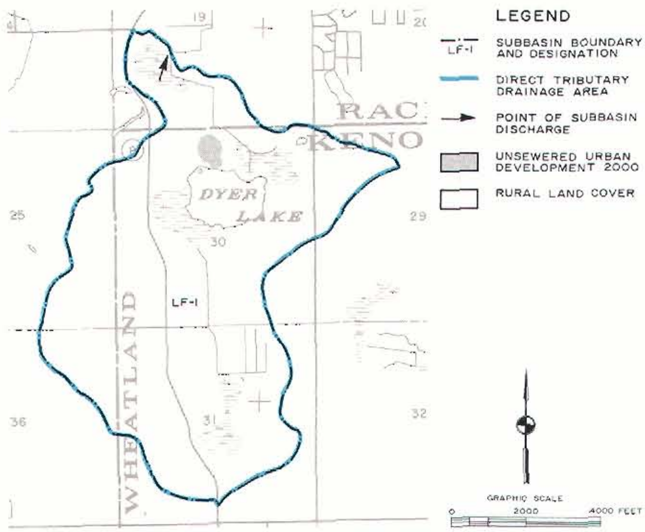
| Characteristic | Description |
|---|---|
| Surface Area | 56 acres |
| Direct Tributary Drainage Area | 1,353 acres |
| Shoreline | 1.16 miles |
| Depth | |
| Maximum | 13 feet |
| Mean | 5 feet |
| Volume | 275 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 46 persons |
| General Existing Water Quality Conditions: | Excessive macrophyte growth; frequent fish winterkill; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-17

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF DYER LAKE: 2000




Dyer Lake has a direct tributary drainage area of about 1,353 acres. About 1,296 acres, or 96 percent of the drainage area, are planned to be in rural land cover, and 57 acres, or four percent, to be in urban land cover. Over the planning period none of the direct tributary drainage area is expected to be converted to urban land cover. It is estimated that a 75 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and sound agricultural cropping practices.

*Source: SEWRPC.*

Table C-50

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO DYER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 57 | 3 | 0.4 | 57 | 33 | 0.4 |
| Land under Development—Construction Activities (acres) | — | — | — | — | — | — |
| Onsite Sewage Disposal Septic Tank Systems[b] | — | — | — | — | — | — |
| Rural Land Cover (acres) | 1,296 | 178 | 26.1 | 1,296 | 178 | 26.1 |
| Livestock Operations (animal units) | 72 | 475 | 69.4 | 72 | 475 | 69.4 |
| Atmospheric Contribution (acres of receiving surface water) | 56 | 28 | 4.1 | 56 | 28 | 4.1 |
| Total | — | 684 | 100.0 | — | 684 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

tinue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.08 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Dyer Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-51, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake.

Table C-51

WATER QUALITY MANAGEMENT MEASURES FOR DYER LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 80 |
| Livestock Waste Control | $ 6,300 | $ 500 | $ 4,700 | $ 6,400 | $ 11,100 | $ 300 | $ 400 | $ 700 | | |
| Rural Conservation Practices[b] | 13,200 | 4,500 | 9,800 | 55,300 | 65,100 | 600 | 3,500 | 4,100 | | |
| Total | 19,500 | 5,000 | 14,500 | 61,700 | 76,200 | 900 | 3,900 | 4,800 | | |
| Macrophyte Harvesting[c] | 23,300 | 3,300 | 17,400 | 52,000 | 69,400 | 1,100 | 3,300 | 4,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[d] | 5,000 | 100 | 3,700 | 1,600 | 5,300 | 200 | 100 | 300 | Prevent fish winter kill due to anaerobic (lack of oxygen) conditions | No additional reduction |
| Sediment Covering[e,g] | 112,000 | — | 83,700 | — | 83,700 | 5,300 | — | 5,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f] | 903,500 | — | 675,000 | — | 675,000 | 42,800 | — | 42,800 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of septic tank systems is recommended to help improve the water quality of Dyer Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Dyer Lake drainage basin include a minimal capital cost over the period of 1975-2000 an average annual operation and maintenance cost of $400, and a total 50-year present worth cost of $14,000.*

[b] *Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 25 acres of Dyer Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate 25 acres of the lake.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 5 feet.*

[g] *The cost of sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate and amount of fill or dredged material required.*

*Source: SEWRPC.*

Other needed measures include: improved septic tank management and measures to reduce pollutant runoff from rural lands by 50 percent.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned diffuse source controls. Alternative restoration measures as set forth in Table C-51 may include dredging, sediment covering, and aeration to alleviate the existing fish winterkill problem. The feasibility of these measures would have to be assessed in a preliminary engineering study. Macrophyte harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Dyer Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Dyer Lake would entail a total capital cost of about $19,500, and an average annual operation and maintenance cost of about $5,000. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $76,200 with an equivalent annual cost of $4,800. If, in addition rehabilitation costs were found to be necessary, the capital cost of these alternatives would range from $5,000 for aeration to $903,300 for dredging. The total present worth costs of lake rehabilitation techniques would range from $5,300 for aeration to $675,000 for dredging.

Eagle Lake

Eagle Lake is a 520-acre lake located in the Town of Dover in Racine County. The lake drains to the Fox River via Eagle Creek. Certain geomorphological characteristics of Eagle Lake are set forth in Table C-52 together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[3] Map C-18 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-18, all significant year 2000 urban land areas in the tributary watershed area are proposed to be served by sanitary sewers.

As of 1975, an estimated 450 privately owned onsite sewage disposal systems—390 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-53, all sources combined contribute about 2,272 pounds of phosphorus annually to Eagle Lake during an average year of precipitation. These pollutant loads were estimated based on data developed

Table C-52

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF EAGLE LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 520 acres |
| Direct Tributary Drainage Area | 2,910 acres |
| Shoreline | 4.37 miles |
| Depth | |
| Maximum | 15 feet |
| Mean | 7.0 feet |
| Volume | 3,640 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,620 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; frequent fish winterkill; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.6 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-53

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO EAGLE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 318 | 50 | 2.2 | 756 | 278 | 12.0 |
| Land under Development—Construction Activities (acres) | – | – | – | 27 | 600 | 26.0 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 390 | 565 | 24.9 | 17 | 25 | 1.1 |
| Rural Land Cover (acres) | 2,592 | 455 | 20.0 | 2,127 | 203 | 8.8 |
| Livestock Operations (animal units) | 357 | 942 | 41.5 | 357 | 942 | 40.8 |
| Atmospheric Contribution (acres of receiving surface water) | 520 | 260 | 11.4 | 520 | 260 | 11.3 |
| Total | – | 2,272 | 100.0 | – | 2,308 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

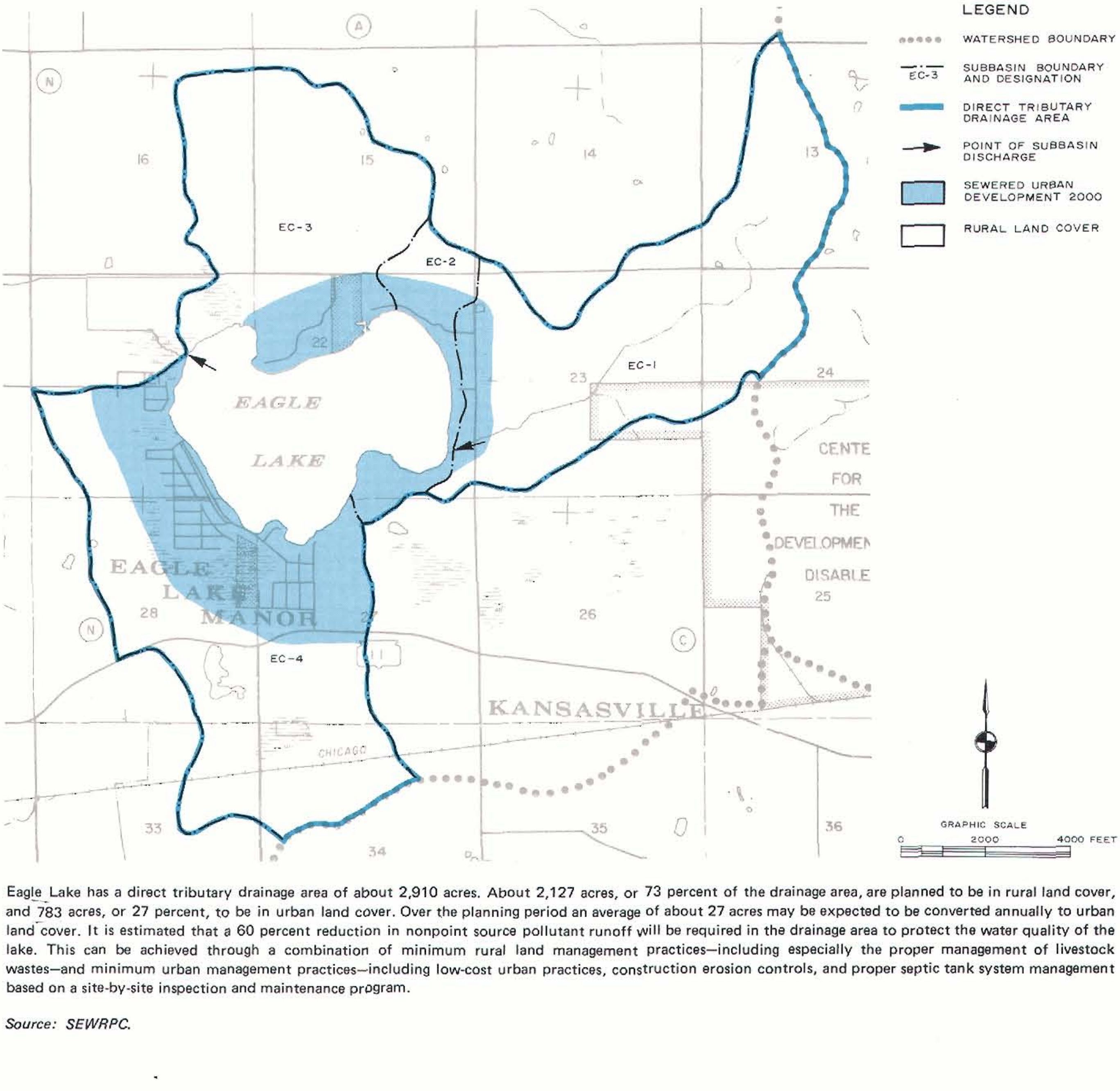
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

[3] *See separately published SEWRPC Community Assistance Planning Report on Water Quality Management for Eagle Lake, Racine County, for a more detailed discussion of the findings and recommendations of the detailed field study.*

Map C-18

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF EAGLE LAKE: 2000




Eagle Lake has a direct tributary drainage area of about 2,910 acres. About 2,127 acres, or 73 percent of the drainage area, are planned to be in rural land cover, and 783 acres, or 27 percent, to be in urban land cover. Over the planning period an average of about 27 acres may be expected to be converted annually to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

during detailed field studies—conducted during a period of below average precipitation—interpreted against general pollutant source loading estimates for the lake watershed for average typical year conditions.

Also, as indicated in Table C-53, urban land uses in the watershed are expected to more than double under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to increase to about 2,308 pounds as a result of the increased construction activity. Loadings from construction activities needed for the development of urban land as well as livestock operations are expected to be a major source of phosphorus in the lake under anticipated year 2000 conditions. The observed total phosphorus concentration during study year 1976 spring overturn was 0.05 milligram per liter (mg/l), which is also the expected phosphorus concentration under anticipated year 2000 conditions. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Eagle Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-54, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. When this problem is confirmed through further local study, the specific lake restoration or rehabilitation procedures which are appropriate should be identified for application, after implementation of the above-mentioned point and diffuse source controls. In addition to continued fish management, alternative restoration measures as set forth in Table C-54 may include sediment covering and/or dredging. Chemical treatment to control algae can be used if necessary, but only as a temporary solution to the problem. The feasibility of these measures would have to be assessed in a preliminary engineering study.

**Table C-54**

**WATER QUALITY MANAGEMENT MEASURES FOR EAGLE LAKE IN RACINE COUNTY**

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis, Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protects public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 70 |
| Livestock Waste Control | $ 31,400 | $ 2,700 | $ 23,500 | $ 31,500 | $ 55,000 | $ 1,500 | $ 2,000 | $ 3,500 | | |
| Minimum Rural Conservation Practices | 500 | 4,200 | 400 | 51,300 | 51,700 | <100 | 3,300 | 3,300 | | |
| Construction Erosion Control Practices | 1,247,400 | 10,800 | 936,300 | 170,200 | 1,106,500 | 59,400 | 10,800 | 70,200 | | |
| Low Cost Urban Land Management Practices | Minimal | 800 | Minimal | 12,100 | 12,100 | Minimal | 800 | 800 | | |
| Total | 1,279,300 | 18,500 | 960,200 | 265,100 | 1,225,300 | 61,000 | 16,900 | 77,800 | | |
| Continued Fish Management Program | Minimal | | Minimal | | | Minimal | | | Improve water clarity, recreational use and aesthetic characteristics | No additional reduction |
| Sediment Covering[e,g] | 1,040,000 | – | 777,200 | – | 777,200 | 49,300 | – | 49,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 6,710,100 | – | 5,014,400 | – | 5,014,400 | 318,100 | – | 318,100 | Deepen lake; reduce macrophyte growth | No additional reduction |

*[a] The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

*[b] Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Eagle Lake drainage basin include a capital cost over the period of 1975-2000 of $1,384,000, an average annual operation and maintenance cost of $10,400, and a total 50-year present worth cost of $939,000.*

*[c] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Eagle Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Eagle Lake drainage basin include a capital cost over the period of 1975-2000 of $76,500, an average annual operation and maintenance cost of $1,600, and a total 50-year present worth cost of $95,600.*

*[d] Cost estimated to control erosion from the estimated 27 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*[e] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[f] Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 7 feet. Actual costs may be higher depending upon lake physiography.*

*[g] The cost for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

It should be emphasized, however, that the long-term maintenance of water quality in Eagle Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Eagle Lake would entail a total capital cost of about $1,279,300, and an average annual operation and maintenance cost of about $18,500. The total 50-year present worth cost of these nonpoint source control measures is $1,225,300, with an equivalent annual cost of $77,800. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $1,040,000 for sediment covering to $6,710,000 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $777,200 for sediment covering to $5,014,400 for dredging.

Eagle Spring Lake

Eagle Spring Lake is a 310-acre lake located in the Town of Eagle in Waukesha County. The lake drains through the Mukwonago River to the Fox River. Certain geomorphological characteristics of Eagle Spring Lake are set forth in Table C-55, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-19 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-19 none of the year 2000 urban land in the tributary watershed area is proposed to be served by sanitary sewers. As of 1975, an estimated 309 privately owned onsite sewage disposal systems—98 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the watershed area.

As indicated in Table C-56, all direct tributary sources combined contribute about 8,200 pounds of phosphorus annually to Eagle Spring Lake. The major source of phosphorus in the lake watershed is livestock operations. An additional 90 pounds of phosphorus are added to the basin as discharge from Lulu Lake. Land uses in the watershed are not expected to change significantly under planned year 2000 land cover conditions, therefore the estimated total phosphorus loadings for the future are not significantly different from present loads. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.19 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Eagle Spring Lake which exceed the recommended level for recreational use and for maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-57, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, measures to reduce pollutant runoff from rural lands by 75 percent, and low-cost measures to reduce pollutant runoff from urban lands.

Table C-55

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF EAGLE SPRING LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 310 acres |
| Direct Tributary Drainage Area | 5,859 acres |
| Shoreline | 4.0 miles |
| Depth | |
| Maximum | 8 feet |
| Mean | 3.6 feet |
| Volume | 1,127 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,118 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; potential of winter fishkills |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.62 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-56

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO EAGLE SPRING LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 496 | 146 | 1.8 | 496 | 146 | 1.8 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 98 | 284 | 3.5 | 98 | 284 | 3.5 |
| Rural Land Cover (acres) | 5,363 | 1,335 | 16.3 | 5,363 | 1,335 | 16.3 |
| Livestock Operations (animal units) | 950 | 6,270 | 76.5 | 950 | 6,270 | 76.5 |
| Atmospheric Contribution (acres of receiving surface water) | 310 | 155 | 1.9 | 310 | 155 | 1.9 |
| Total | – | 8.190[c] | 100.0 | – | 8.190[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

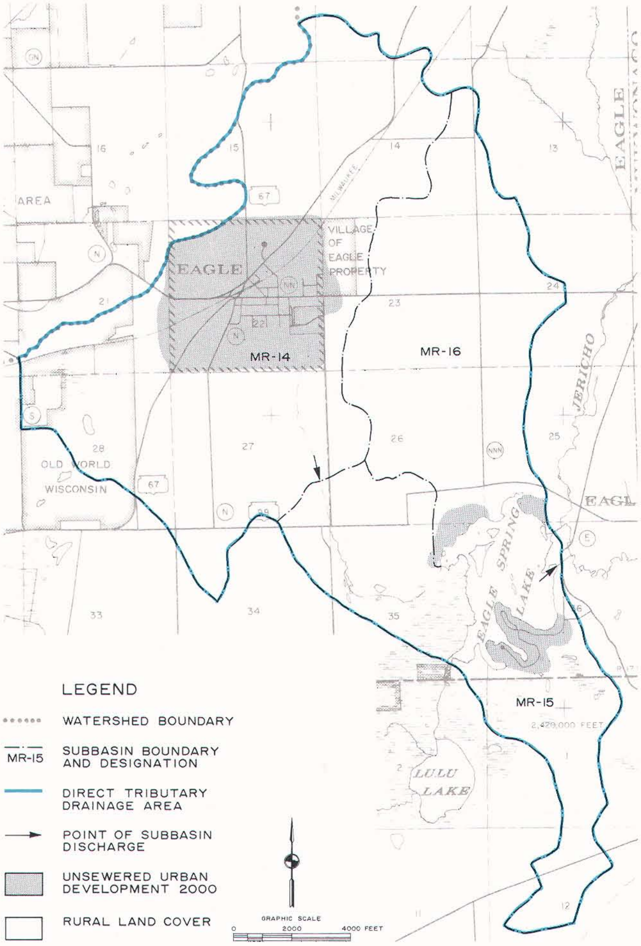
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 and year 2000 anticipated phosphorus load of less than 100 pounds annually contributed from the outflow of Lulu Lake.*

*Source: SEWRPC.*

## Map C-19

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF EAGLE SPRING LAKE: 2000




Eagle Spring Lake has a direct tributary drainage area of about 5,859 acres. About 5,363 acres, or 92 percent of the drainage area, are planned to be in rural land cover, and 496 acres, or 8 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will probably provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and diffuse source controls. Alternative restoration measures as set forth in Table C-57 may include sediment covering, aeration, and nutrient inactivation. Dredging to remove nutrient rich sediments and deepen the lake could significantly improve lake quality. However, the lake is so shallow at present that extensive dredging which would more than triple the lake volume would be required. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional measures, such as weed harvesting, may be used to control macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Eagle Spring Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Eagle Spring Lake would entail a total capital cost of about $721,800, and an average annual operation and maintenance cost of about $91,000. The total 50-year present worth cost of these nonpoint source control measures is $1,118,400, with an equivalent annual cost of $70,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $20,000 for aeration to $5,700,300 for dredging. The total present worth costs of these lake rehabilitation techniques would be $22,800 for aeration and $4.3 million for dredging.

Echo Lake

Echo Lake is a 71-acre shallow impoundment on the White River and Honey Creek in the City and Town of Burlington in Racine County. Certain geomorphological characteristics of Echo Lake are set forth in Table C-58, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-20 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-20, all significant urban land areas in the direct tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 83 privately owned onsite sewage disposal systems—12 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-59, all direct tributary sources combined contribute about 5,630 pounds of phosphorus annually to Echo Lake. The major source of phosphorus was runoff from livestock operations. However, the White River and Honey Creek are tributary to the lake and over 25,400 pounds of phosphorus are annually contributed to the lake by these inlet streams. Because of the large drainage area and the relatively small size and depth of Echo Lake, the lake flushes often, thereby transporting a large portion of these pollutants through the lake. The impoundment is severely silted, however, and recreational use is restricted. Also, as indicated in Table C-59, urban land uses in the direct tributary watershed are expected to increase by about 28 percent under planned year 2000

Table C-57

WATER QUALITY MANAGEMENT MEASURES FOR EAGLE SPRING LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 90 |
| Livestock Waste Control | $ 83,600 | $ 7,100 | $ 65,100 | $ 83,900 | $ 149,000 | $ 4,100 | $ 5,300 | $ 9,400 | | |
| Rural Conservation Practices[b] | 638,200 | 83,100 | 537,400 | 419,900 | 957,300 | 34,100 | 26,600 | 60,700 | | |
| Low Cost Urban Land Management Practices | – | 800 | – | 12,100 | 12,100 | – | 800 | 800 | | |
| Total | 721,800 | 91,000 | 602,500 | 515,900 | 1,118,400 | 38,200 | 32,700 | 70,900 | | |
| Macrophyte Harvesting[c] | 233,000 | 32,500 | 174,100 | 512,300 | 686,400 | 11,000 | 32,500 | 43,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[d] | 20,000 | 500 | 14,900 | 7,900 | 22,800 | 900 | 500 | 1,400 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[e] | 31,000 | – | 23,200 | – | 23,200 | 1,500 | – | 1,500 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,h] | 620,000 | – | 463,300 | – | 463,300 | 29,400 | – | 29,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 5,700,300 | – | 4,259,900 | – | 4,259,900 | 270,200 | – | 270,200 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Eagle Spring Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Eagle Spring Lake drainage basin include a capital cost over the period of 1975-2000 of $441,000, an average annual operation and maintenance cost of $10,200, and a total 50-year present worth cost of $595,200.*

[b] *Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 250 acres of Eagle Spring Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate 100 acres of the lake.*

[e] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 3.6 feet.*

[h] *The costs of dredging and sediment covering vary widely depending on such factors as lake size and type, type of bottom substrate, and the amount of material to be dredged or filled.*

*Source: SEWRPC.*

land cover conditions. However, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock sources may be expected to continue to be the primary direct tributary source of phosphorus to the lake under anticipated year 2000 conditions. The upstream load is expected to be reduced to 11,100 pounds of phosphorus per year under year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from stream inflow and direct drainage phosphorus loadings and lake and drainage basin characteristics, is 0.16 milligram per liter (mg/l) and 0.09 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less for a recreational use, and a warmwater fishery and aquatic life classification. The year 2000 conditions represent the extension of sanitary sewer service to most of the direct tributary area and a 50 percent reduction in surface diffuse source loads to the White River and Honey Creek watersheds, as estimated in the Fox River watershed steam water quality management element. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Echo Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Because of the excessive total phosphorus loadings from the upstream tributary area of the White River and Honey Creek, Echo Lake cannot realistically achieve the necessary 0.02 mg/l total phosphorus level necessary for the full recreational use and warmwater fishery classification. Therefore, the Commission has recommended that Echo Lake be classified as a limited recreational

## Table C-58

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF ECHO LAKE

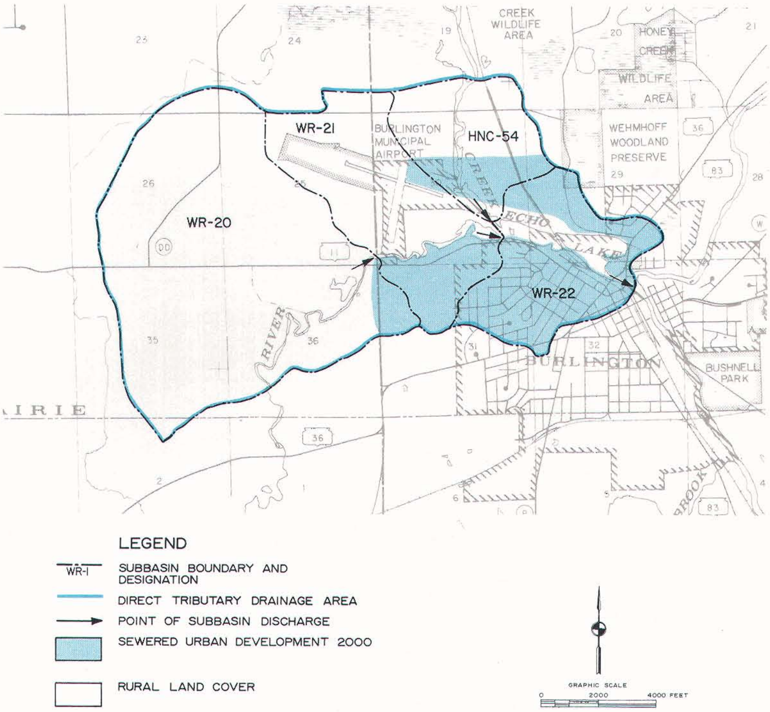
| Characteristic | Description |
|---|---|
| Surface Area | 71 acres |
| Direct Tributary Drainage Area | 3,476 acres |
| Shoreline | 2.46 miles |
| Depth | |
| Maximum | 11 feet |
| Mean | 1.8 feet |
| Volume | 128.8 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 2,407 persons |
| General Existing Water Quality Conditions: | Extreme turbidity, which limits aquatic plant growth and a desirable fishery. Because of the high flushing rate, the water quality resembles that of a stream rather than that of a lake |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.38 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Map C-20

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF ECHO LAKE: 2000




Echo Lake has a direct tributary drainage area of about 3,476 acres. About 2,664 acres, or 77 percent of the drainage area, are planned to be in rural land cover, and 812 acres, or 23 percent, to be in urban land cover. Over the planning period an average of about 20 acres may be expected to be converted annually to urban land cover. A combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

## Table C-59

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO ECHO LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 619 | 393 | 7.0 | 792 | 503 | 8.8 |
| Land under Development—Construction Activities (acres) | 20 | 909 | 16.1 | 20 | 909 | 15.9 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 12 | 35 | 0.6 | 11 | 32 | 0.6 |
| Rural Land Cover (acres) | 2,837 | 285 | 5.1 | 2,664 | 254 | 4.5 |
| Livestock Operations (animal units) | 602 | 3,973 | 70.6 | 602 | 3,973 | 69.6 |
| Atmospheric Contribution (acres of receiving surface water) | 71 | 35 | 0.6 | 71 | 36 | 0.6 |
| Total | – | 5,630[c] | 100.0 | – | 5,707[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the estimated 1975 phosphorus load of 25,400 pounds per year or the year 2000 anticipated phosphorus load of 11,100 pounds per year contributed from the Honey Creek and the White River drainage area.*

*Source: SEWRPC.*

use and warmwater fishery lake, for which expensive diffuse source control measures are probably not warranted.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-60, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conserva-

Table C-60

WATER QUALITY MANAGEMENT MEASURES FOR ECHO LAKE IN RACINE COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 30 |
| Livestock Waste Control | $ 86,600 | $ 6,800 | $ 64,700 | $ 79,600 | $ 144,300 | $ 4,100 | $ 5,000 | $ 9,100 | | |
| Minimum Rural Conservation Practices and Stream Protection | 18,600 | 4,800 | 13,800 | 58,500 | 72,300 | 900 | 3,700 | 4,600 | | |
| Construction Erosion Control Practices[d] | 1,155,000 | 10,000 | 866,900 | 157,600 | 1,024,500 | 55,000 | 10,000 | 65,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,200 | Minimal | 17,200 | 17,200 | Minimal | 1,100 | 1,100 | | |
| Total | 1,260,200 | 22,800 | 945,400 | 312,900 | 1,258,300 | 60,000 | 19,800 | 79,800 | | |
| Lake Drawdown | Minimal | | Minimal | | | Minimal | | | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Echo Lake drainage basin include a capital cost over the period of 1975-2000 of $3,752,000, an average annual operation and maintenance cost of $47,000, and a total 50-year present worth cost of $2,843,200.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Echo Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Echo Lake drainage basin include a capital cost over the period of 1975-2000 of $49,500, an average annual operation and maintenance cost of $1,200, and a total 50-year present worth cost of $70,100.*

[d] *Cost estimated to control erosion from the estimated 25 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*Source: SEWRPC.*

tion practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

The application of most lake restoration or rehabilitation procedures at this time should be considered with caution, since the problems would probably reoccur rapidly. However, drawdown, with subsequent fish restocking and bottom sediment removal or consolidation, may provide some measure of temporary water quality improvement. Inflow treatment is another alternative restoration technique which may be applicable to Echo Lake. The feasibility of these measures would have to be assessed in a preliminary engineering study.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Echo Lake would entail a total capital cost of about $1,260,200, and an average annual operation and maintenance cost of about $22,800. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $1,258,300, with an equivalent annual cost of $79,800. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would be minimal for lake drawdown measures.

Elizabeth Lake

Elizabeth Lake is a 638-acre lake located in the Town of Randall in Kenosha County, with the southern portion located in Illinois. The lake drains south via a tributary to the North Branch of Nippersink Creek. Certain geomorphological characteristics of Elizabeth Lake are set forth in Table C-61, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-21 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-21, a major portion of urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 86 privately owned onsite sewage disposal systems—17 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-62, all sources combined contribute about 3,300 pounds of phosphorus annually to Elizabeth Lake. The major sources of phosphorus in the lake watershed are livestock operations and construction activities. An additional 180 pounds of phosphorus are discharged to the watershed from Marie Lake. Also, as indicated in Table C-62, urban land uses in the watershed are expected to increase by about 62 percent under

Table C-61

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF ELIZABETH LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 638 acres |
| Direct Tributary Drainage Area | 5,029 acres |
| Shoreline | 5.4 miles |
| Depth | |
| Maximum | 32 feet |
| Mean | 11 feet |
| Volume | 6,900 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,441 persons |
| General Existing Water Quality Conditions: | Frequent algae blooms; moderate nutrient concentrations; oxygen depletion in hypolimnion during summer |

*[a] The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-62

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO ELIZABETH LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 599 | 159 | 4.9 | 969 | 165 | 5.3 |
| Land under Development—Construction Activities (acres) | 25 | 1,080 | 33.1 | 25 | 1,080 | 34.9 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 17 | 49 | 1.5 | 11 | 32 | 1.0 |
| Rural Land Cover (acres) | 4,400 | 627 | 19.2 | 4,030 | 471 | 15.2 |
| Livestock Operations (animal units) | 156 | 1,030 | 31.5 | 156 | 1,030 | 33.3 |
| Atmospheric Contribution (acres of receiving surface water) | 638 | 319 | 9.8 | 638 | 319 | 10.3 |
| Total | – | 3,264[c] | 100.0 | – | 3,097[c] | 100.0 |

*[a] Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

*[b] Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*[c] Does not include the 1975 estimated phosphorus load of 180 pounds per year or the year 2000 anticipated phosphorus load of 45 pounds per year contributed by the upstream drainage area of Marie Lake.*

*Source: SEWRPC.*

planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be decreased to about 3,100 pounds. The Marie Lake discharge to the watershed is expected to be reduced to 45 pounds by the year 2000 due to implementation of diffuse source controls upstream of the lake. The proposed extension of sanitary sewer service will eliminate all but a total 40 septic tank systems by the year 2000. Loadings from the construction activities are expected to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.06 milligram per liter (mg/l) and 0.05 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a recreational use and warmwater fishery and aquatic life classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Elizabeth Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

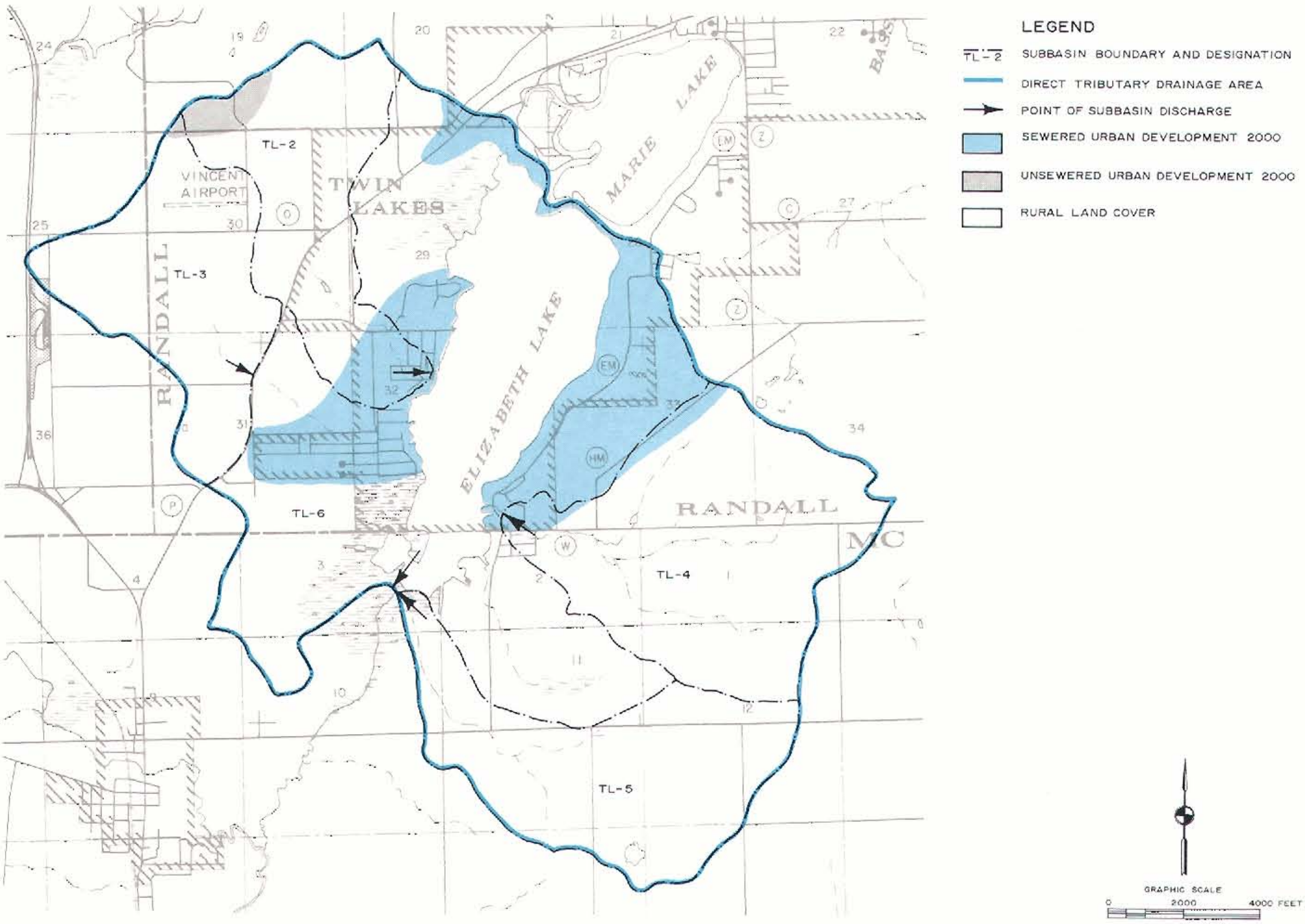
The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-63, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source of excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures would be considered, in addition to the above point and diffuse source controls. Alternative restoration measures as set forth in Table C-63 may include sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Elizabeth Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Elizabeth Lake would entail a total capital cost of

Map C-21

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF ELIZABETH LAKE: 2000




Elizabeth Lake has a direct tributary drainage area of about 5,024 acres. About 4,030 acres, or 80 percent of the drainage area, are planned to be in rural land cover, and 994 acres, or 20 percent, to be in urban land cover. Over the planning period an average of about 25 acres may be expected to be converted annually to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

about $1,169,600, and an average annual operation and maintenance cost of about $20,200. The total 50-year present worth cost of these nonpoint source control measures is $1,162,300, with an equivalent annual cost of $67,900. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $13,400 for nutrient inactivation to $1,276,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would be from $10,000 for nutrient inactivation to $953,600 for sediment covering.

Lake Geneva

Lake Geneva is a 5,262-acre lake located in the Towns of Linn, Geneva, and Walworth in Walworth County. The lake drains to the White River. Certain geomorphological characteristics of Lake Geneva are set forth in Table C-64, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[4,5] Map C-22 presents

[4]*See separately published SEWRPC Community Assistance Planning Report on Water Quality Management for Lake Geneva, Walworth County, for a more detailed discussion of the findings and recommendations of the detailed field study.*

[5]*Report on Lake Geneva, Walworth County; National Eutrophication Survey, U.S. Environmental Protection Agency, 1972.*

## Table C-63

### WATER QUALITY MANAGEMENT MEASURES FOR ELIZABETH LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | — | — | — | — | — | — | — | — | Protect public health and drinking water supplies; reduce nutrient concentrations | — |
| Septic Tank System Management[c] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 75 |
| Livestock Waste Control | $ 13,700 | $ 1,200 | $ 10,300 | $ 13,800 | $ 24,100 | $ 700 | $ 900 | 1,600 | | |
| Minimum Rural Conservation Practices | 900 | 7,700 | 700 | 93,900 | 94,600 | 100 | 6,000 | 6,100 | | |
| Construction Erosion Control Practices[d] | 1,155,000 | 10,000 | 866,900 | 157,600 | 1,024,500 | 55,000 | 10,000 | 65,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,300 | Minimal | 19,100 | 19,100 | Minimal | 1,200 | 1,200 | | |
| Total | 1,169,600 | 20,200 | 877,900 | 284,400 | 1,162,300 | 55,800 | 18,100 | 73,900 | | |
| Hypolimnetic Aeration[e] | 26,800 | 700 | 20,000 | 11,000 | 31,000 | 1,300 | 700 | 2,000 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 13,400 to 63,800 | — | 10,000 to 47,700 | — | 10,000 to 47,700 | 600 to 3,000 | | 600 to 3,000 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,h] | 1,276,000 | — | 953,600 | — | 953,600 | 60,500 | — | 60,500 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Elizabeth Lake drainage basin include a capital cost over the period of 1975-2000 of $184,000, an average annual operation and maintenance cost of $11,900, and a total 50-year present worth cost of $290,400.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Elizabeth Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Elizabeth Lake drainage basin include a capital cost over the period of 1975-2000 of $45,500, an average annual operation and maintenance cost of $1,300, and a total 50-year present worth cost of $72,100.*

[d] *Cost estimated to control erosion from the estimated 25 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to aerate the entire hypolimnion of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *The costs of sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of fill required.*

*Source: SEWRPC.*

a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-22, all of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 1,647 privately owned onsite sewage disposal systems—661 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-65, all sources combined contribute an estimated 19,000 pounds of phosphorus annually to Lake Geneva during an average year of precipitation. These pollutant loads were estimated based on data developed during detailed field studies—conducted during a period of below average precipitation—and general pollutant source loading estimates for the lake watershed for average or typical year conditions.

As indicated in Table C-65, urban land uses are expected to increase by about 22 percent under planned year 2000 land cover conditions. The annual phosphorus load, however, is expected to be reduced to about 15,000 pounds as a result of the extension of sanitary sewers and the elimination of the Fontana Sewage Treatment Plant seepage lagoon discharge to Buena Vista Creek. The observed total phosphorus concentration during study year 1976 spring overturn was 0.02 milligram per liter (mg/l), which is representative of a dry year condition. The water quality simulation analyses indicated that,

### Table C-64

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE GENEVA

| Characteristic | Description |
|---|---|
| Surface Area | 5,262 acres |
| Direct Tributary Drainage Area | 12,750 acres |
| Shoreline | 20.2 miles |
| Depth | |
| Maximum | 135 feet |
| Mean | 61 feet |
| Volume | 320,982 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 12,231 persons |
| General Existing Water Quality Conditions: | Generally good, with occasional algae blooms, and some nuisance macrophyte growth |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.00 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Table C-65

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE GENEVA: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 4,920 | 1,554 | 8.0 | 6,002 | 1,895 | 12.5 |
| Land under Development—Construction Activities (acres) | 29 | 1,318 | 6.9 | 29 | 1,318 | 8.7 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 661 | 1,914 | 10.0 | 63 | 182 | 1.2 |
| Rural Land Cover (acres) | 7,801 | 957 | 5.0 | 6,719 | 747 | 4.9 |
| Livestock Operations (animal units) | 1,263 | 8,336 | 44.0 | 1,263 | 8,336 | 55.3 |
| Atmospheric Contribution (acres of receiving surface water) | 5,262 | 2,631 | 13.9 | 5,262 | 2,631 | 17.4 |
| Fontana Sewage Treatment Plant | – | 2,323 | 12.2 | – | – | – |
| Total | – | 19,033 | 100.0 | – | 15,109 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC*

### Table C-66

### WATER QUALITY MANAGEMENT MEASURES FOR LAKE GENEVA IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | | |
| Livestock Waste Control | $ 173,300 | $ 13,700 | $ 129,600 | $ 160,500 | $ 290,100 | $ 8,200 | $ 10,200 | $ 18,400 | | |
| Minimum Rural Conservation Practices | 1,800 | 15,000 | 1,300 | 783,400 | 784,700 | 100 | 11,600 | 11,700 | | |
| Construction Erosion Control Practices[d] | 1,339,800 | 11,600 | 1,005,600 | 182,800 | 1,188,400 | 63,800 | 11,600 | 75,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 6,800 | Minimal | 100,800 | 100,800 | Minimal | 6,400 | 6,400 | | |
| Total | 1,514,900 | 47,100 | 1,136,500 | 1,227,500 | 2,364,000 | 72,100 | 39,800 | 111,900 | | 70 |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Lake Geneva drainage basin include a capital cost over the period of 1975-2000 of $10,436,000, an average annual operation and maintenance cost of $151,200, and a total 50-year present worth cost of $8,230,200.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Geneva. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Geneva drainage basin include a capital cost over the period of 1975-2000 of $283,500, an average annual operation and maintenance cost of $5,500, and a total 50-year present worth cost of $346,000.*

[d] *Cost estimated to control erosion from the estimated 29 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*Source: SEWRPC.*

during a year of average precipitation, the spring phosphorus concentration would approximate 0.04 mg/l under existing conditions and 0.03 mg/l under anticipated year 2000 conditions. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a trout fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Geneva which slightly exceed the recommended level for recreational use and for the maintenance of a trout fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-66, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, the abatement of the seepage overflow from the Fontana Sewage Treatment Plant by the addition of additional seepage lagoon capacity; improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

Lake Geneva currently has few serious limitations to its use as a fishery and recreational resource. It is not expected that lake restoration or rehabilitation measures will be necessary to augment its high quality. It should be emphasized, however, that the long-term maintenance of water quality in Lake Geneva requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lake Geneva would entail a total capital cost of about $1,514,900, and an average annual operation and maintenance cost of about $47,100. The total 50-year present worth cost of these source control measures is $2,364,000, with an equivalent annual cost of $111,900.

## Kee Nong Go Mong Lake

Kee Nong Go Mong Lake, sometimes referred to as "Long Lake," is an 88-acre lake located in the Town of Norway in Racine County. The lake drains to Wind Lake Drainage Canal through Waubeesee Lake. Certain geomorphological characteristics of Kee Nong Go Mong Lake are set forth in Table C-67, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-23 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-23, a major portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 158 privately owned onsite sewage disposal systems—115 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-68, all direct tributary sources combined contribute about 2,820 pounds of phosphorus annually to Kee Nong Go Mong Lake. The major sources of phosphorus in the lake watershed are rural land runoff and runoff from livestock operations. In addition,

**Table C-67**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF KEE NONG GO MONG LAKE**

| Characteristic | Description |
|---|---|
| Surface Area | 88 acres |
| Direct Tributary Drainage Area | 1,337 acres |
| Shoreline | 2.5 miles |
| Depth | |
| Maximum | 25 feet |
| Mean | 8.7 feet |
| Volume | 770 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 569 persons |
| General Existing Water Quality Conditions: | Excessive macrophyte growth; recent water quality data are not available for Kee Nong Go Mong Lake |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.6 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

**Table C-68**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO KEE NONG GO MONG LAKE: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 131 | 130 | 4.6 | 145 | 144 | 5.7 |
| Land under Development—Construction Activities (acres) | – | – | – | 1 | 48 | 1.9 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 115 | 333 | 11.8 | 3 | 9 | 0.3 |
| Rural Land Cover (acres) | 1,206 | 1,184 | 42.0 | 1,191 | 1,169 | 46.0 |
| Livestock Operations (animal units) | 171 | 1,129 | 40.0 | 171 | 1,129 | 44.4 |
| Atmospheric Contribution (acres of receiving surface water) | 88 | 44 | 1.6 | 88 | 44 | 1.7 |
| Total | – | 2,820[c] | 100.0 | – | 2,543[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

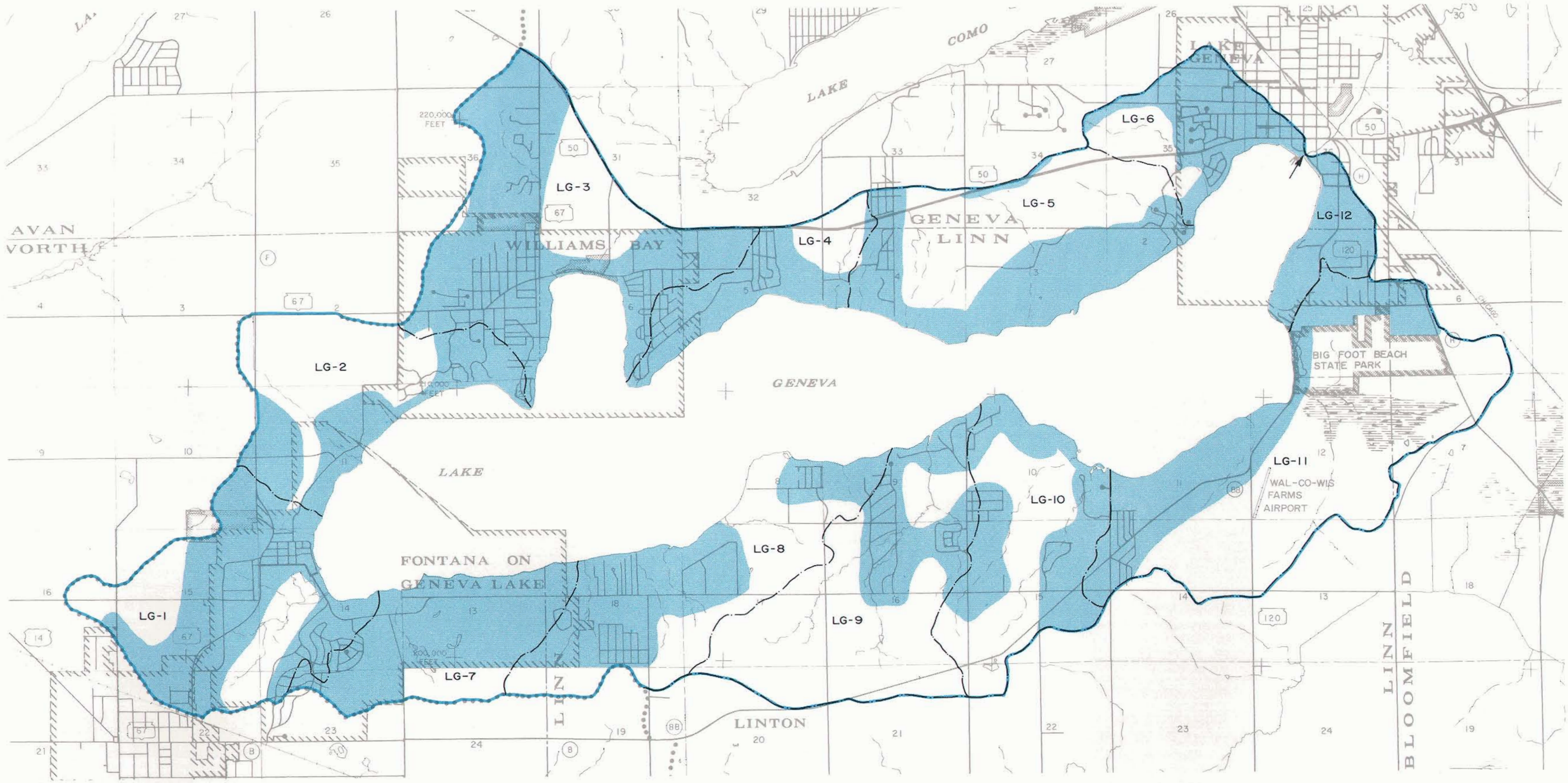
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 260 pounds per year or the year 2000 anticipated phosphorus load of about 30 pounds per year contributed by the Lake Denoon Drainage.*

*Source: SEWRPC.*

Map C-22

# PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE GENEVA




LEGEND

- WATERSHED BOUNDARY
- LG - 2 SUBBASIN BOUNDARY AND DESIGNATION
- DIRECT TRIBUTARY DRAINAGE AREA
- POINT OF SUBBASIN DISCHARGE
- SEWERED URBAN DEVELOPMENT 2000
- RURAL LAND COVER

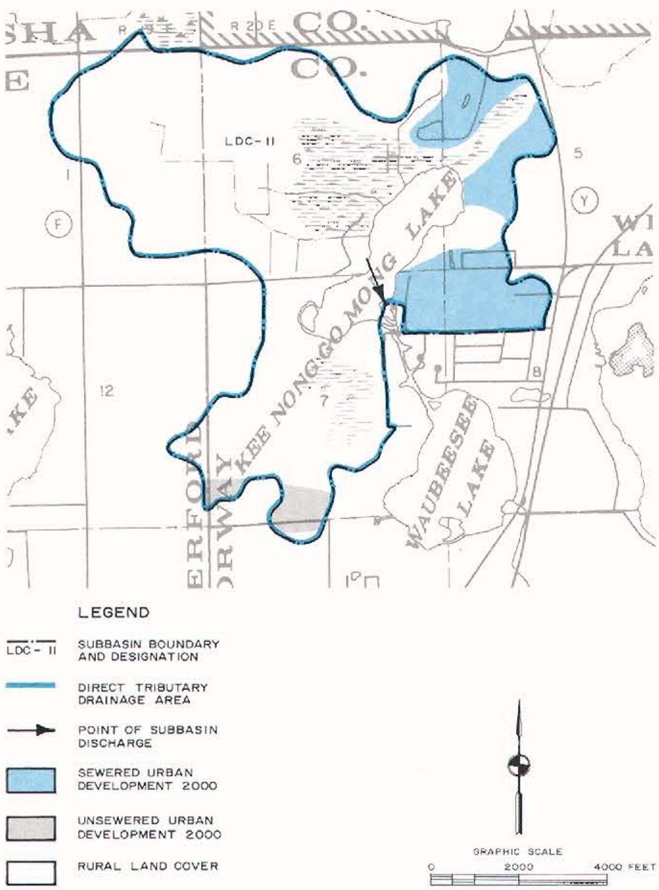
GRAPHIC SCALE
0 2000 4000 FEET

Lake Geneva has a direct tributary drainage area of about 12,750 acres. About 6,719 acres, or 53 percent of the drainage area, are planned to be in rural land cover, and 6,031 acres, or 47 percent, to be in urban land cover. Over the planning period an average of about 29 acres may be expected to be converted annually to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake during average precipitation year conditions. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Map 23

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF KEE NONG GO MONG LAKE: 2000**




Lake Kee Nong Go Mong has a direct tributary drainage area of about 1,337 acres. About 1,191 acres, or 89 percent of the drainage area, are planned to be in rural land cover, and 146 acres, or 11 percent, to be in urban land cover. Over the planning period an average of about one acre may be expected to be converted annually to urban land cover. A combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

260 pounds of total phosphorus are estimated to be contributed to the lake from Lake Denoon drainage. Also, as indicated in Table C-68, urban land uses in the watershed are expected to increase slightly under planned year 2000 land use conditions. Annual total phosphorus loadings to the lake are expected to be reduced slightly in the year 2000 due to the provision of sanitary sewer service, as well as an expected 90 percent decrease in the phosphorus discharge from Lake Denoon. Loadings from rural land runoff and livestock operations are expected to remain the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentratons during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.24 milligram per liter (mg/l) and 0.19 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Kee Nong Go Mong Lake which greatly exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. Because of the excessive total phosphorus loadings from the diffuse source loads within the entire tributary watershed, Lake Kee Nong Go Mong cannot realistically achieve the necessary 0.02 mg/l total phosphorus level necessary for the full recreational use and warmwater fishery classification. Therefore, the Commission has recommended that Lake Kee Nong Go Mong be classified as a limited recreational use and warmwater fishery lake, for which expensive nonpoint sources control measures are probably not warranted.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake was made, and a set of recommended measures was identified. These measures are set forth in Table C-69, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above diffuse source controls. Alternative restoration measures, as set forth in Table C-69, may include dredging, hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Kee Nong Go Mong Lake requires that the recommended level of nutrient input reductions be achieved.

## Table C-69

## WATER QUALITY MANAGEMENT MEASURES FOR KEE NONG GO MONG LAKE IN RACINE COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; reduce the potential for the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 15,000 | $ 1,300 | $ 11,300 | $ 15,100 | $ 26,400 | $ 700 | $ 1,000 | $ 1,700 | | |
| Minimum Rural Conservation Practices | 200 | 2,100 | 200 | 25,700 | 25,900 | < 100 | 1,600 | 1,700 | | |
| Construction Erosion Control Practices[d] | 46,200 | 400 | 34,700 | 6,300 | 41,000 | 2,200 | 400 | 2,600 | | 90 |
| Low Cost Urban Land Management Practices | – | 200 | – | 3,400 | 3,400 | – | 200 | 200 | | |
| Total | 61,400 | 4,000 | 46,200 | 50,500 | 96,700 | 3,000 | 3,200 | 6,200 | | |
| Macrophyte Harvesting[e] | 18,600 | 2,600 | 13,900 | 41,000 | 54,900 | 900 | 2,600 | 3,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 2,000 | <100 | 1,500 | 800 | 2,300 | 100 | <100 | 200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 8,800 | – | 6,600 | – | 6,600 | 400 | – | 400 | Accelerate lake improvement; prevent release of nutrients from sediment, remove nutrients from water body | No additional reduction |
| Sediment Covering[h,j] | 176,000 | – | 131,500 | – | 131,500 | 8,300 | – | 8,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[i,j] | 887,200 | – | 663,000 | – | 663,000 | 42,100 | – | 42,100 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Kee Nong Go Mong Lake drainage basin include a capital cost over the period of 1975-2000 of $488,000, an average annual operation and maintenance cost of $3,700, and a total 50-year present worth cost of $331,100.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Kee Nong Go Mong Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Kee Nong Go Mong Lake drainage basin include a capital cost over the period of 1975-2000 of $117,000, an average annual operation and maintenance cost of $1,900, and a total 50-year present worth cost of $133,000.*

[d] *Cost estimated to control erosion from the estimated one acre of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 20 acres of Kee Nong Go Mong Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate 10 acres of the lake.*

[g] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 8.75 feet.*

[j] *The costs for dredging and sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Kee Nong Go Mong Lake entail a total capital cost of about $61,400, and an average annual operation and maintenance cost of about $4,000. The total 50-year present worth cost of these diffuse control measures is $96,700, with an equivalent annual cost of $6,200. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $2,000 for hypolimnetic aeration to $887,200 for dredging. The total present worth costs of these lake rehabilitation techniques would be from $2,300 for hypolimnetic aeration to $663,000 for dredging.

### Lauderdale Lakes

The Lauderdale Lakes complex is an 834-acre system of three lakes, Green, Middle and Mill Lakes, located in the Towns of LaGrange and Sugar Creek in Walworth County. Certain geomorphological characteristics of the Lauderdale Lakes are set forth in Table

Table C-70

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF THE LAUDERDALE LAKES

| Characteristic | Description |
|---|---|
| Surface Area | 834 acres |
| Direct Tributary Drainage Area | 5,429 acres |
| Shoreline | 16 miles |
| Depth | |
| Maximum | 57 feet |
| Mean | 15 feet |
| Volume | 12,591 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 4,463 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; moderate high nutrient concentrations; oxygen depletion in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

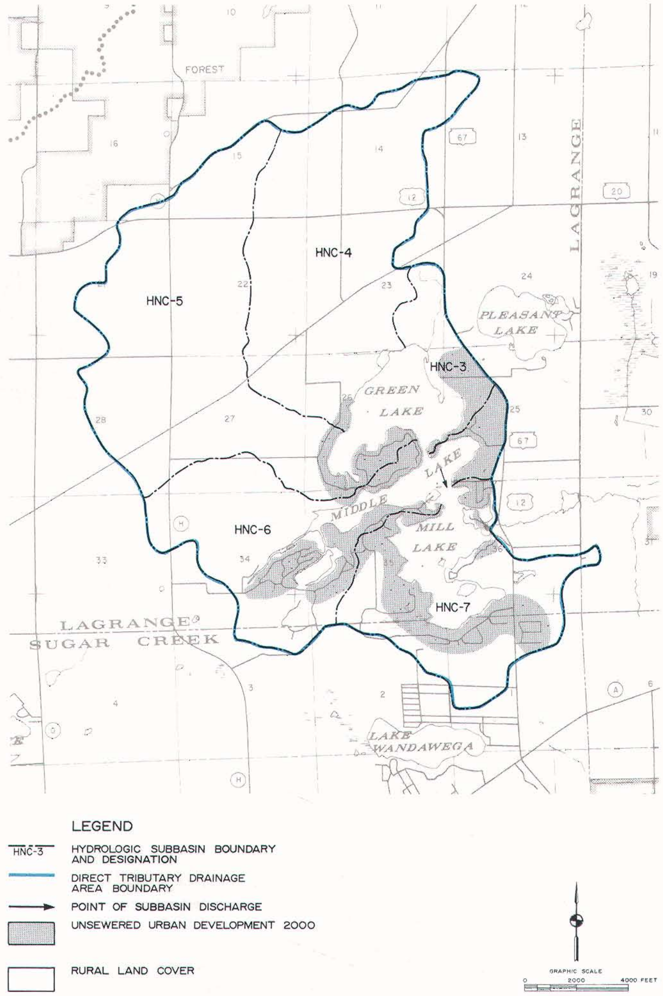
*Source: SEWRPC.*

C-70, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[6] Map C-24 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-24, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 1,426 privately owned onsite sewage disposal systems—1,328 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the watershed area.

As indicated in Table C-71, all sources combined contribute about 7,500 pounds of phosphorus annually to the Lauderdale Lakes. The major sources of phosphorus in the lake watershed are septic systems and runoff from livestock activities. Also, as indicated in Table C-71, the existing land uses are not expected to change significantly under planned year 2000 land use conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from septic tanks and livestock may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.11 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be

Map 24

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA IN THE LAUDERDALE LAKES: 2000




The Lauderdale Lakes have a direct tributary drainage area of about 5,429 acres. About 4,669 acres, or 86 percent of the drainage area, are planned to be in rural land cover, and 760 acres, or 14 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and mininum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

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[6]*Report on Middle Lake, National Eutrophication Survey, U.S. Environmental Protection Agency, 1975.*

### Table C-71

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAUDERDALE LAKES: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) . . . . . . . . . . . . . | 760 | 88 | 1.2 | 760 | 88 | 1.2 |
| Land under Development—Construction Activities (acres) . . . . . . . . . . . . . . . . . | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] . . . . . . . . . . . . . . . . . | 1,328 | 3,845 | 51.3 | 1,328 | 3,845 | 51.3 |
| Rural Land Cover (acres) . . . . . . . . . . . . . | 4,669 | 480 | 6.4 | 4,669 | 480 | 6.4 |
| Livestock Operations (animal units) . . . . . . | 402 | 2,653 | 35.5 | 402 | 2,653 | 35.5 |
| Atmospheric Contribution (acres of receiving surface water) . . . . . . . . . . . . | 834 | 417 | 5.6 | 834 | 417 | 5.6 |
| Total | – | 7,483 | 100.0 | – | 7,483 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC*

expected to result in total phosphorus concentrations in the Lauderdale Lakes which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-72, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

### Table C-72

### WATER QUALITY MANAGEMENT MEASURES FOR THE LAUDERDALE LAKES IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 35,400 | $ 3,000 | $ 26,500 | $ 35,500 | $ 62,000 | $ 1,700 | $ 2,300 | $ 4,000 | | |
| Minimum Rural Conservation Practices | 1,000 | 8,200 | 700 | 99,700 | 100,400 | <100 | 6,300 | 6,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,300 | Minimal | 18,500 | 18,500 | Minimal | 1,200 | 1,200 | | |
| Total | 36,400 | 12,500 | 27,200 | 153,700 | 180,900 | 1,800 | 9,800 | 11,600 | | 80 |
| Macrophyte Harvesting[b] | 233,000 | 32,500 | 174,100 | 512,300 | 686,400 | 11,000 | 32,500 | 43,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 45,000 | 1,100 | 33,600 | 17,300 | 50,900 | 2,100 | 1,100 | 3,200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 22,500 to 83,400 | – | 16,800 to 62,300 | – | 16,800 to 62,300 | 1,100 to 4,000 | – | 1,100 to 4,000 | Accelerate lake improvement; prevent release of nutrients from sediment, remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 1,668,000 | – | 1,246,500 | – | 1,246,500 | 79,100 | – | 79,100 | Accelerate lake improvement; prevent release of nutrients from sediment, reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of the Lauderdale Lakes. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lauderdale Lake drainage basin include a capital cost over the period of 1975-2000 of $5,976,000, an average annual operation and maintenance cost of $56,000, and a total 50-year present worth cost of $5,311,400.*

[b] *Cost estimated to harvest macrophytes from the 250 acres of the Lauderdale Lakes subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[e] *Cost estimate to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs of sediment covering vary depending on such factors as lake size and depth, type of bottom substrate, and the amount of material to be filled.*

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the abovementioned diffuse source controls. Alternative restoration measures as set forth in Table C-72 may include dredging, sediment covering, and nutrient inactivation. In addition, hypolimnetic aeration of the lower layers of the lakes may be necessary to eliminate anaerobic conditions. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in the Lauderdale Lakes requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to the Lauderdale Lakes would entail a total capital cost of about $36,400, and an average annual operation and maintenance cost of about $12,500. The total 50-year present worth cost of these diffuse source control measures, useful in comparing the long-term costs of alternative control measures, is $180,900 with an equivalent annual cost of $11,600. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $22,500 for nutrient inactivation to $1,668,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would be from $16,800 for nutrient inactivation to $1,246,500 for sediment covering.

## Lilly Lake

Lilly Lake is an 88-acre lake located in the Town of Wheatland in Kenosha County. Certain geomorphological characteristics of Lilly Lake are set forth in Table C-73, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-25 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-25 none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 207 privately owned onsite sewage disposal systems—101 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-74, all sources combined contribute about 400 pounds of phosphorus loadings annually to Lilly Lake. The major sources of phorphorus in the lake watershed is septic tank systems. Also, as indicated in Table C-74, septic tank systems may be expected to continue to be the primary sources of phosphorus to

### Table C-73

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LILLY LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 88 acres |
| Direct Tributary Drainage Area | 307 acres |
| Shoreline | 1.3 miles |
| Depth | |
| Maximum | 6 feet |
| Mean | 4.7 feet |
| Volume | 415 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 685 persons |
| General Existing Water Quality Conditions: | Dense macrophyte growth; occasional fish winterkill during severe winters; high nutrient concentrations; large deposits of organic material on lake bottom |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Table C-74

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LILLY LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 107 | 42 | 10.3 | 107 | 42 | 10.3 |
| Land under Development—Construction Activies (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 101 | 292 | 72.0 | 101 | 292 | 72.0 |
| Rural Land Cover (acres) | 200 | 28 | 6.9 | 200 | 28 | 6.9 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 88 | 44 | 10.8 | 88 | 44 | 10.8 |
| Total | – | 406 | 100.0 | – | 406 | 100.0 |

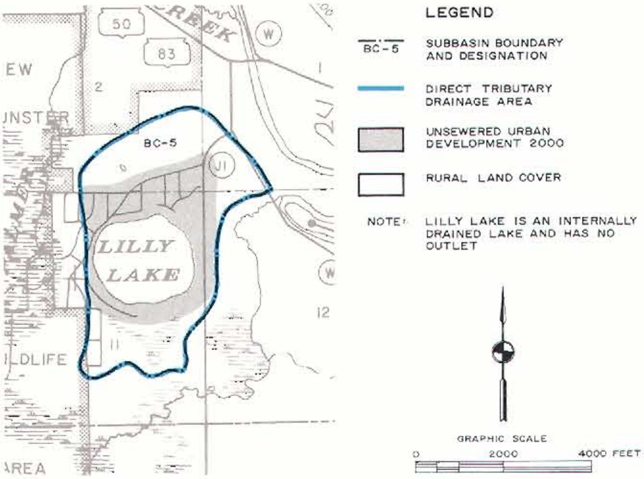
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC*

## Map C-25

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LILLY LAKE: 2000




Lilly Lake has a direct tributary drainage area of about 307 acres. About 200 acres, or 65 percent of the drainage area, are planned to be in rural land cover, and 107 acres, or 35 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.05 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lilly Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-75, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

## Table C-75

### WATER QUALITY MANAGEMENT MEASURES FOR LILLY LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 75 |
| Minimum Rural Conservation Practices | $ < 100 | $ < 100 | $ < 100 | $ 800 | $ 900 | $ < 100 | $ < 100 | $ 200 | | |
| Low Cost Urban Land Management Practices | Minimal | 200 | Minimal | 2,600 | 2,600 | — | 200 | 200 | | |
| Total | 100 | 300 | 100 | 3,400 | 3,500 | 100 | 300 | 400 | | |
| Nutrient Inactivation[b] | 4,400 | — | 3,300 | — | 3,300 | 200 | — | 200 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[c,e] | 176,000 | — | 131,500 | — | 131,500 | 8,300 | — | 8,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[d] | 550,000 | — | 411,000 | — | 411,000 | 26,100 | — | 26,100 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lilly Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lilly Lake drainage basin include a capital cost over the period of 1975-2000 of $454,500, an average annual operation and maintenance cost of $7,200, and a total 50-year present worth cost of $502,200.*

[b] *The cost for nutrient inactivation is for treating one half of the lakes area with alum.*

[c] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[d] *Cost to dredge the lake is the actual cost for Lilly Lake Project.*

[e] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom sediment, and amount of material to be filled.*

*Source: SEWRPC.*

As of 1978, Lilly Lake was undergoing dredging to a maximum depth of 15 feet as part of its inland lake restoration program.[7] If nutrients continue to be released from the sediment following dredging, sediment covering or nutrient inactivation may be considered as additional inlake rehabilitation techniques. It should be emphasized, however, that the long-term maintenance of water quality in Lilly Lake requires that the recommended level of nutrient input reductions also be achieved in order to maintain water suitable for all facets of recreational use and a warmwater fishery.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Lilly Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $300. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $3,500, with an equivalent annual cost of $400. The estimated capital cost of the currently ongoing dredging project is estimated at $550,000. If additional rehabilitation techniques prove necessary, these measures could be expected to entail a capital cost which would range from $4,400 for nutrient inactivation to $176,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $3,300 for nutrient inactivation to $131,500 for sediment covering.

Little Muskego Lake

Little Muskego Lake is a 506-acre lake located in the City of Muskego in Waukesha County. The lake is fed by and drains to Muskego Creek. Certain geomorphological characteristics of Little Muskego Lake are set forth in Table C-76, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[8] Map C-26 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-26, the majority of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 904 privately owned onsite sewage disposal systems—450 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-77, all direct tributary sources combined contribute about 11,500 pounds of phosphorus annually to Little Muskego Lake. The major direct tributary source of phosphorus in the lake

[7] *Grant application to the EPA Clean Lakes Program for the Lilly Lake Protection and Rehabilitation District, Department of Natural Resources, 1975.*

[8] *The Removal of Sediment and Muck From Little Muskego Lake, Kendziorski, C., Jr. P.E., 1967.*

Table C-76

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LITTLE MUSKEGO LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 506 acres |
| Direct Tributary Drainage Area | 7,067 acres |
| Shoreline | 5.7 miles |
| Depth | |
| Maximum | 65 feet |
| Mean | 15 feet |
| Volume | 7,170 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 10,353 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.92 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-77

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LITTLE MUSKEGO LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 2,519 | 1,800 | 15.7 | 3,845 | 2,176 | 21.7 |
| Land under Development—Construction Activities (acres) | 75 | 3,382 | 29.5 | 75 | 3,382 | 33.8 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 450 | 1,303 | 11.3 | 44 | 127 | 1.3 |
| Rural Land Cover (acres) | 4,473 | 2,343 | 20.4 | 3,147 | 1,677 | 16.7 |
| Livestock Operations (animal units) | 364 | 2,402 | 20.9 | 364 | 2,402 | 24.0 |
| Atmospheric Contribution (acres of receiving surface water) | 506 | 253 | 2.2 | 506 | 253 | 2.5 |
| Total | – | 11,483 | 100.0 | – | 10,017 | 100.0 |

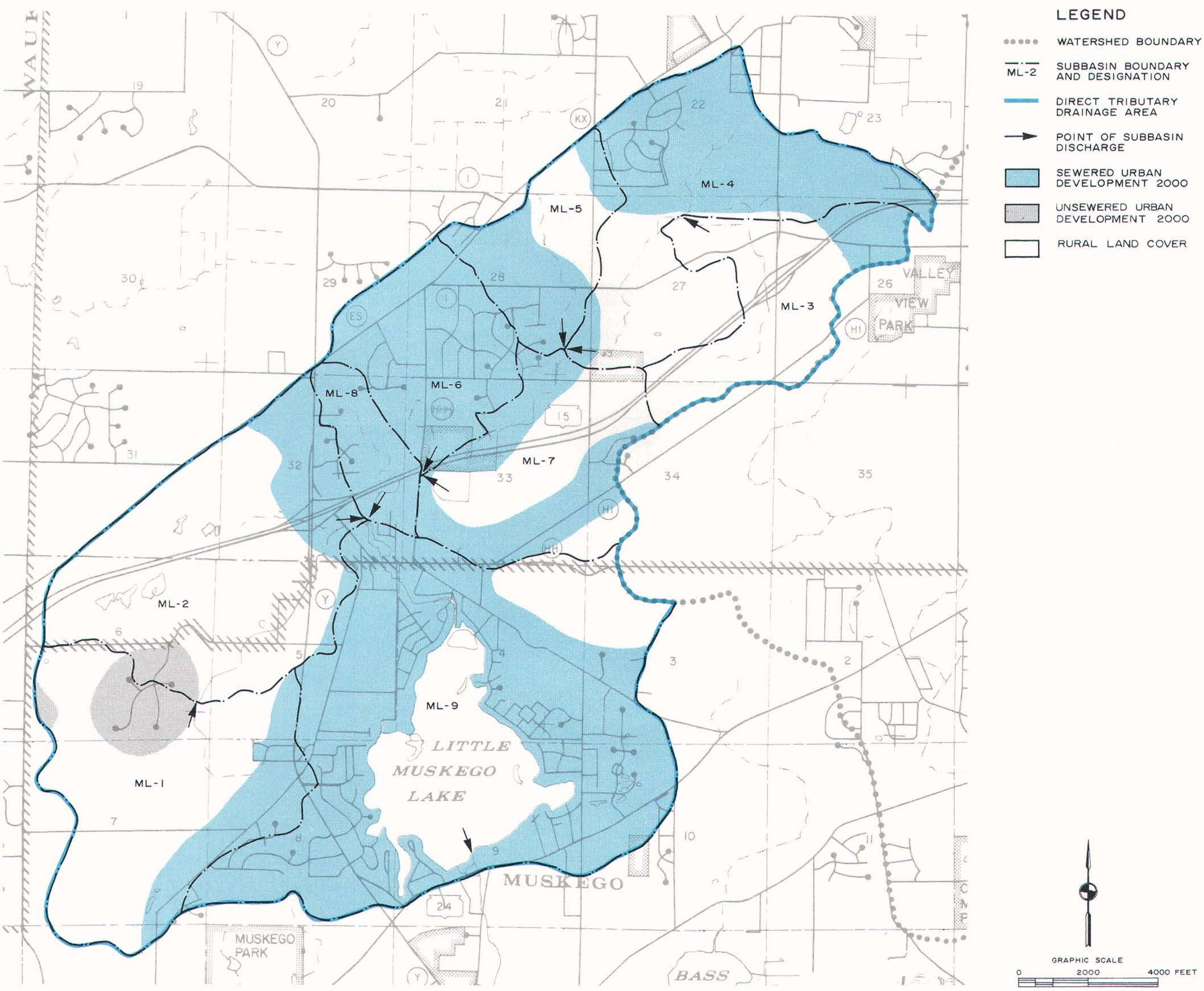
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-26

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LITTLE MUSKEGO LAKE: 2000




Little Muskego Lake has a direct tributary drainage area of about 7,067 acres. About 3,147 acres, or 45 percent of the drainage area, are planned to be in rural land cover, and 3,845 acres, or 55 percent, to be in urban land cover. Over the planning period an average of about 75 acres may be expected to be converted annually to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices— including especially the proper management of livestock wastes—and urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

watershed is construction activities. Also, as indicated in Table C-77, urban land uses in the watershed are expected to increase by about 50 percent under planned year 2000 land use conditions, with annual total phosphorus loadings to the lake expected to be reduced to about 10,000 pounds, as a result of the extension of sanitary sewer service. Pollutant loadings from construction activities are expected to continue to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.21 milligram per liter (mg/l) and 0.17 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Little Muskego Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-78, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, measures to reduce pollutant runoff from rural lands by 75

**Table C-78**

**WATER QUALITY MANAGEMENT MEASURES FOR LITTLE MUSKEGO LAKE IN WAUKESHA COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 32,000 | $ 2,700 | $ 24,000 | $ 32,100 | $ 56,100 | $ 1,500 | $ 2,000 | $ 3,500 | | |
| Rural Conservation Practices[d] | 455,500 | 59,300 | 383,600 | 298,600 | 682,200 | 24,300 | 19,000 | 43,300 | | |
| Construction Erosion Control Practices[e] | 3,465,000 | 30,000 | 2,600,700 | 472,900 | 3,073,600 | 165,000 | 30,000 | 195,000 | | |
| Low Cost Urban Land Management Practices | – | 5,300 | – | 77,900 | 77,900 | – | 4,900 | 4,900 | | |
| Additional Urban Land Management Practices[f] | 110,500 | 56,500 | 78,500 | 663,500 | 742,000 | 5,000 | 42,000 | 47,000 | | 80 |
| Total | 4,063,000 | 153,800 | 3,086,800 | 1,545,000 | 4,631,800 | 195,800 | 97,900 | 293,700 | | |
| Macrophyte Harvesting[g] | 139,800 | 19,500 | 104,500 | 307,400 | 411,900 | 6,600 | 19,500 | 26,100 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[h] | 26,300 | 700 | 19,700 | 11,000 | 30,700 | 1,300 | 700 | 1,900 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[i] | 13,200 to 50,600 | – | 10,000 to 37,800 | – | 10,000 to 37,800 | 600 to 2,400 | – | 600 to 2,400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[j,k] | 1,012,000 | – | 756,300 | – | 756,300 | 48,000 | – | 48,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[l,m] | 2,290,000 | – | 1,711,300 | – | 1,711,300 | 108,600 | – | 108,600 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Milwaukee Metropolitan subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Little Muskego Lake drainage basin include a capital cost over the period of 1975-2000 of $8,384,000, an average annual operation and maintenance cost of $115,000, and a total 50-year present worth cost of $6,510,100.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Little Muskego Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Little Muskego Lake drainage basin include a capital cost over the period of 1975-2000 of $198,000, an average annual operation and maintenance cost of $3,400, and a total 50-year present worth cost of $224,500.*

[d] *Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads.*

[e] *Cost estimated to control erosion from the estimated 75 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[f] *Urban land management practices necessary to achieve a 50 percent reduction in urban diffuse source pollutant loads.*

[g] *Cost estimated to harvest macrophytes from the 150 acres of Little Muskego Lake subject to excessive macrophyte growth.*

[h] *Cost estimated to aerate the entire hypolimnion of the lake.*

[i] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[j] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[k] *The costs of sediment covering vary widely depending on lake size and depth, type of bottom material, and amount of fill required.*

[l] *Cost of present contract to dredge portions of Little Muskego Lake.*

[m] *Strand Associates, Inc., Preliminary Engineering and Environmental Impact Report for Little Muskego Lake, Muskego, Wisconsin, August 1978.*

*Source: SEWRPC.*

percent, low-cost measures to reduce pollutant runoff from urban lands, additional measures to reduce pollutant runoff from urban lands by 50 percent, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been desposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-78 may include sediment covering hypolimnetic aeration, dredging, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Little Muskego Lake requires that the recommended level of nutrient input reductions be achieved. In recognition of the importance of the sediments as a pollutant source, and to enhance the recreational use of the lake, the Little Muskego Lake Association, acting on the basis of the findings of an Environmental Impact Assessment study, initiated a project, with financial assistance of the US EPA for dredging of shallow areas in the lake which currently exhibit problems of excessive macrophyte growth. The dredging, estimated to have a total capital cost of $2,290,000, will remove a significant portion of the nutrients already in the lake sediments and reduce the potential for macrophyte growth.

The application of the above listed nonpoint source pollution control measures to control the nutrient input to Little Muskego Lake would entail a total capital cost of about $4,063,000, and an average annual operation and maintenance cost of about $153,800. The total 50-year present worth cost of these nonpoint source control measures is $4,631,800, with an equivalent annual cost of $293,700. If, in addition rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $13,200 for nutrient inactivation to $2,290,000 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $10,000 for nutrient inactivation of $1,711,300 for dredging.

Long Lake

Long Lake is a 102-acre lake located in the Towns of Burlington and Rochester in Racine County. The lake drains to the Fox River. Certain geomorphological characteristics of Long Lake are set forth in Table C-79, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-27 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-27 none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 14 privately owned onsite sewage disposal systems—eight of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-80, all sources combined contribute about 2,800 pounds of phosphorus annually to Long Lake. The major source of phosphorus in the

Table C-79

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LONG LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 102 acres |
| Tributary Drainage Area | 1,858 acres |
| Shoreline | 3.4 miles |
| Depth | |
| Maximum | 5 feet |
| Mean | 2.5 feet |
| Volume | 258.5 acre-feet |
| Approximate 1975 Population of Direct Tributary Watershed[a] | 50 persons |
| General Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; fish winterkill during severe winters; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.50 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-80

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LONG LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 467 | 92 | 3.3 | 467 | 92 | 3.3 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 8 | 23 | 0.8 | 8 | 23 | 0.8 |
| Rural Land Cover (acres) | 1,391 | 458 | 16.2 | 1,391 | 458 | 16.2 |
| Livestock Operations (animal units) | 334 | 2,204 | 77.9 | 334 | 2,204 | 77.9 |
| Atmospheric Contribution (acres of receiving surface water) | 102 | 51 | 1.8 | 102 | 51 | 1.8 |
| Total | – | 2,828 | 100.0 | – | 2,828 | 100.0 |

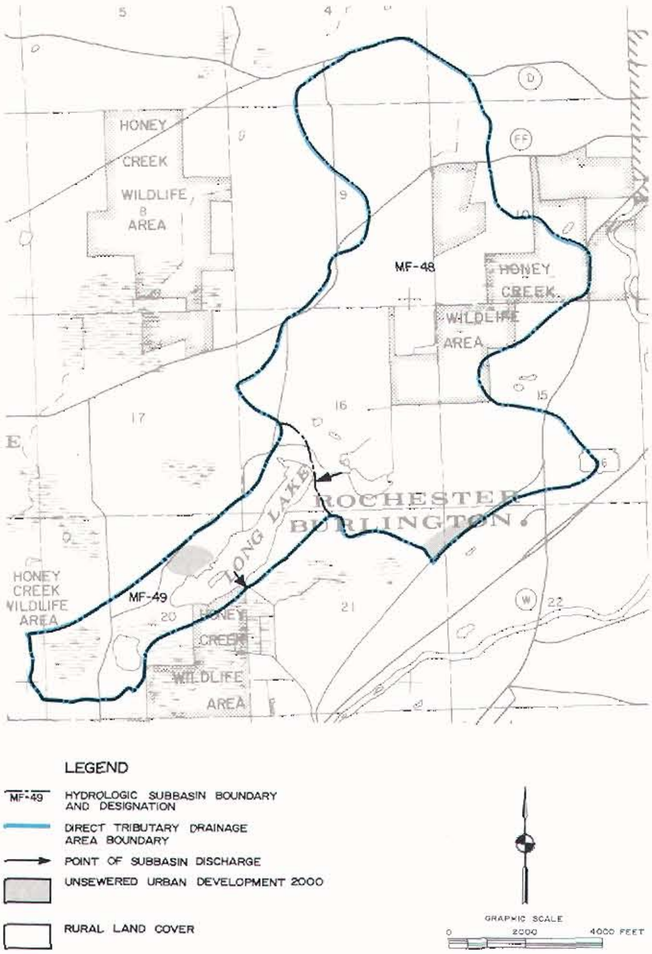
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-27

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LONG LAKE: 2000




Long Lake has a direct tributary drainage area of about 1,858 acres. About 1,391 acres, or 75 percent of the drainage area, are planned to be in rural land cover, and 467 acres, or 25 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

lake watershed is livestock sources. Also as indicated in Table C-80, the existing land uses are not expected to change significantly under planned year 2000 land use conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock operations may be expected to continue to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.21 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a recreational use and maintenance of a warmwater fishery and aquatic life classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Long Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-81, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, measures to reduce pollutant runoff from rural lands by 50 percent and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above diffuse source controls. Alternative restoration measures as set forth in Table C-81 may include dredging and sediment covering. Other rehabilitation techniques such as aeration may be considered to alleviate the existing fish winterkill problem. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Long Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Long Lake would entail a total capital cost of about \$43,600, and an average annual operation and maintenance cost of about \$8,200. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is \$132,900, with an equivalent annual cost of \$8,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from \$5,000 for aeration to \$2,056,600 for

Table C-81

WATER QUALITY MANAGEMENT MEASURES FOR LONG LAKE IN THE TOWNS OF BURLINGTON AND ROCHESTER IN RACINE COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | |
| Livestock Waste Control | $ 29,400 | $ 2,500 | $ 22,000 | $ 29,500 | $ 51,500 | $ 1,400 | $ 1,900 | $ 3,300 | | |
| Rural Conservation Practices[b] | 14,200 | 4,900 | 10,600 | 59,400 | 70,000 | 700 | 3,800 | 4,500 | | |
| Low Cost Urban Land Management Practices | Minimal | 800 | Minimal | 11,400 | 11,400 | Minimal | 700 | 700 | | |
| Total | 43,600 | 8,200 | 32,600 | 100,300 | 132,900 | 2,100 | 6,400 | 8,500 | | 80 |
| Macrophyte Harvesting[c] | 46,600 | 6,500 | 34,800 | 102,500 | 137,300 | 2,200 | 6,500 | 8,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[d] | 5,000 | 100 | 3,700 | 2,000 | 5,700 | 200 | 100 | 400 | Prevent anaerobic conditions, thereby eliminating fish kills | No additional reduction |
| Sediment Covering[e,g] | 204,000 | – | 152,500 | – | 152,500 | 9,700 | – | 129,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f] | 2,056,600 | – | 1,536,900 | – | 1,536,900 | 97,500 | – | 97,500 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Long Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Long Lake drainage basin include a capital cost over the period of 1975-2000 of $36,000, an average annual operation and maintenance cost of $500, and a total 50-year present worth cost of $37,400.*

[b] *Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 50 acres of Long Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate 28 acres of the lake.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 2.5 feet.*

*Source: SEWRPC.*

dredging. The total present worth costs of these lake rehabilitation techniques would range from $5,700 for aeration to $1,536,900 for dredging.

Lulu Lake

Lulu Lake is an 84-acre lake located in the Town of Troy in Walworth County. The lake drains to the Mukwonago River via Eagle Spring Lake. Certain geomorphological characteristics of Lulu Lake are set forth in Table C-82, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-28 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality management plan. The delineated tributary drainage area should be refined in a more detailed, local lake study. As shown on Map C-28 none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 171 privately owned onsite sewage disposal systems—36 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-83, all sources combined contribute about 7,900 pounds of phosphorus annually to Lulu Lake. The major source of phosphorus in the lake watershed is runoff from livestock operations. Also as indicated in Table C-83, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock runoff may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.16 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification.

Lulu Lake appears to be in surprisingly good condition considering the high nutrient load estimated to be entering the lake. This condition is probably a result of the extensive marshland which borders portions of the lake and through which the inlet passes. Depositional and biological uptake processes in marshes may remove a significant amount of pollutants from surface runoff. In addition, Lulu Lake is relatively deep, and the nutrients deposited in the bottom sediments during summer stratification apparently are not substantially released to the water column when spring or fall mixing occurs. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lulu Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-84, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, measures to reduce pollutant runoff from rural lands by 50 percent, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings are reduced, the sediments which may have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-84, may include sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Long Lake requires that the recommended level of nutrient input reduction be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Lulu Lake would entail a total capital cost of about $187,700, and an average annual operation and maintenance cost of about $42,900. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $661,200 with an equivalent annual cost of $41,400. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $5,300 for nutrient inactivation to $168,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $4,000 for nutrient inactivation to $125,000 for dredging.

Table C-82

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LULU LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 84 acres |
| Direct Tributary Drainage Area | 10,317 acres |
| Shoreline | 2.4 miles |
| Depth | |
| Maximum | 40 feet |
| Mean | 24 feet |
| Volume | 2,009 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 585 persons |
| General Existing Water Quality Conditions: | Water quality is generally good; excessive macrophyte growth may occur in some localized areas |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.42 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-83

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LULU LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 270 | 59 | 0.7 | 270 | 59 | 0.7 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 36 | 104 | 1.3 | 36 | 104 | 1.3 |
| Rural Land Cover (acres) | 10,047 | 1,282 | 16.3 | 10,047 | 1,282 | 16.3 |
| Livestock Operations (animal units) | 968 | 6,389 | 81.2 | 968 | 6,389 | 81.2 |
| Atmospheric Contribution (acres of receiving surface water) | 84 | 42 | 0.5 | 84 | 42 | 0.5 |
| Total | – | 7,876 | 100.0 | – | 7,876 | 100.0 |

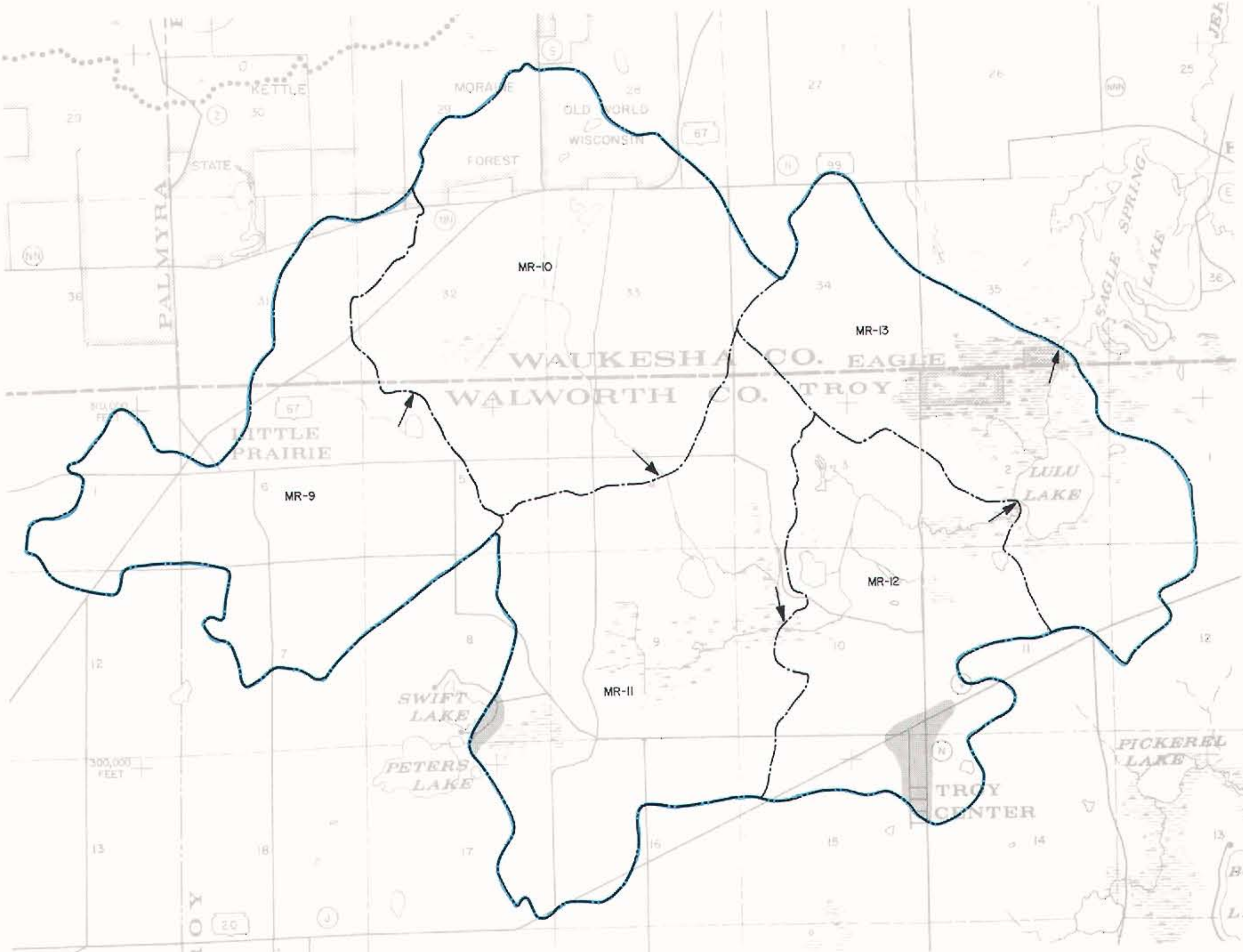
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-28

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LULU LAKE: 2000




LEGEND

- MR-12 HYDROLOGIC SUBBASIN BOUNDARY AND DESIGNATION
- DIRECT TRIBUTARY DRAINAGE AREA BOUNDARY
- POINT OF SUBBASIN DISCHARGE
- UNSEWERED URBAN DEVELOPMENT 2000
- RURAL LAND COVER

GRAPHIC SCALE
0 2000 4000 FEET

Lulu Lake has a direct tributary drainage area of about 10,317 acres. About 10,047 acres, or 97 percent of the drainage area, are planned to be in rural land cover, and 270 acres, or 3 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-84

WATER QUALITY MANAGEMENT MEASURES FOR LULU LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 90 |
| Livestock Waste Control | $ 85,200 | $ 7,300 | $ 63,700 | $ 85,500 | $ 149,200 | $ 4,000 | $ 5,000 | $ 9,000 | | |
| Rural Conservation Practices[b] | 102,500 | 35,200 | 76,400 | 429,000 | 505,400 | 4,800 | 27,200 | 32,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 400 | Minimal | 6,600 | 6,600 | Minimal | 400 | 400 | | |
| Total | 187,700 | 42,900 | 140,100 | 521,100 | 661,200 | 8,800 | 32,600 | 41,400 | | |
| Macrophyte Harvesting[c] | 12,100 | 1,700 | 9,000 | 26,600 | 35,800 | 600 | 1,700 | 2,300 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[d] | 10,600 | 300 | 7,900 | 4,200 | 12,100 | 500 | 300 | 800 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[e] | 5,300 to 8,400 | – | 4,000 to 6,300 | – | 4,000 to 6,300 | 300 to 400 | – | 300 to 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,g] | 168,000 | – | 125,500 | – | 125,500 | 8,000 | – | 8,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lulu Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lulu Lake drainage basin include a capital cost over the period of 1975-2000 of $162,000, an average annual operation and maintenance cost of $5,500, and a total 50-year present worth cost of $275,900.*

[b] *Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 13 acres of Lulu Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate the entire hypolimnion of the lake.*

[e] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

## Marie Lake

Marie Lake is a 315-acre lake located in the Town of Randall in Kenosha County. The lake drains to Elizabeth Lake. Certain geomorphological characteristics of Marie Lake are set forth in Table C-85, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-29 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-29, all significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 11 privately owned onsite sewage disposal systems—two of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-86, all sources combined contribute about 3,200 pounds of phosphorus annually to Marie Lake. The major source of phosphorus in the lake watershed is runoff from livestock operations. Also, as indicated in Table C-86, urban land uses in the watershed are expected to more than double under planned year 2000 land cover conditions and additional sanitary sewer service would be provided. The annual total phosphorus load in 2000 will increase to about 3,400 pounds as a result of urban development. Phosphorus loadings from livestock operations and construction activities may be expected to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.11 milligram per liter (mg/l) and 0.13 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Marie Lake which exceed the recommended level necessary for recreational use and for the maintenance of a warmwater fishery.

Table C-85

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF MARIE LAKE

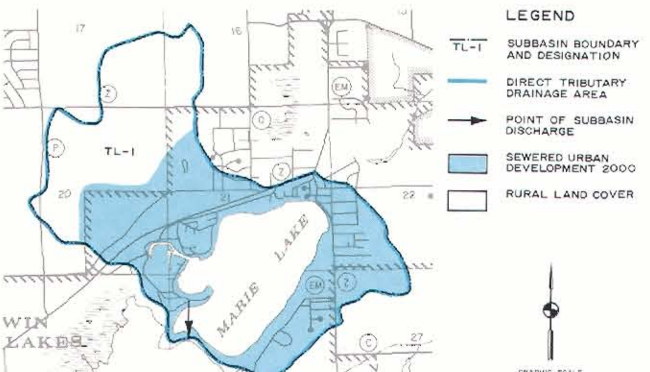
| Characteristic | Description |
|---|---|
| Surface Area . . . . . . . . . . . . | 315 acres |
| Direct Tributary Drainage Area . . . . . . . . . . . . . . . . | 1,143 acres |
| Shoreline . . . . . . . . . . . . . . | 3.5 miles |
| Depth | |
| Maximum . . . . . . . . . . . | 33 feet |
| Mean . . . . . . . . . . . . . . . | 9 feet |
| Volume . . . . . . . . . . . . . . . | 1,957 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] . . . . . | 1,204 persons |
| General Existing Water Quality Conditions: | Occasional moderate algae blooms; high nutrient concentrations; occasional depletion of dissolved oxygen in hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-29

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF MARIE LAKE: 2000




Marie Lake has a direct tributary drainage area of about 1,143 acres. About 304 acres, or 28 percent of the drainage area, are planned to be in rural land cover, and 839 acres, or 72 percent, to be in urban land cover. Over the planning period an average of about 18 acres may be expected to be converted annually to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and construction erosion controls.

*Source: SEWRPC.*

Table C-86

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO MARIE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) . . . . . . . . . . . . | 398 | 112 | 3.4 | 821 | 328 | 9.6 |
| Land under Development—Construction Activities (acres) . . . . . . . . . . . . . . . . | 18 | 816 | 25.2 | 18 | 816 | 24.0 |
| Onsite Sewage Disposal Septic Tank Systems[b] . . . . . . . . . . . . . . . . | 2 | 6 | 0.2 | – | – | – |
| Rural Land Cover (acres) . . . . . . . . . . . . | 727 | 72 | 2.2 | 304 | 27 | 0.8 |
| Livestock Operations (animal units) . . . . . . | 315 | 2,079 | 64.2 | 315 | 2,079 | 61.0 |
| Atmospheric Contribution (acres of receiving surface water) . . . . . . . . . . . . | 315 | 157 | 4.8 | 315 | 157 | 4.6 |
| Total | – | 3,242 | 100.0 | – | 3,407 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-87, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint and point source controls. Alternative restoration measures as set forth in Table C-87, may include nutrient inactivation, sediment covering, and hypolimnetic aeration. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Marie Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Marie Lake would entail a total capital cost of about $859,400, and an average annual operation and maintenance cost of about $11,500. The total 50-year present

Table C-87

WATER QUALITY MANAGEMENT MEASURES FOR MARIE LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Livestock Waste Control | $ 27,700 | $ 2,400 | $ 20,700 | $ 27,800 | $ 48,500 | $ 1,300 | $ 1,800 | $ 3,100 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | 100 | 900 | < 100 | 10,800 | 10,900 | < 100 | 700 | 800 | | |
| Construction Erosion Control Practices[c] | 831,600 | 7,200 | 624,200 | 113,500 | 737,700 | 39,600 | 7,200 | 46,800 | | 85 |
| Low Cost Urban Land Management Practices | Minimal | 1,000 | Minimal | 24,400 | 24,400 | Minimal | 1,600 | 1,600 | | |
| Total | 859,400 | 11,500 | 645,000 | 176,500 | 821,500 | 41,000 | 11,300 | 52,300 | | |
| Hypolimnetic Aeration[e] | 7,700 | 200 | 5,800 | 3,200 | 9,000 | 400 | 200 | 600 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 4,000 to 31,500 | – | 3,000 to 23,500 | – | 3,700 to 23,500 | 200 to 1,500 | – | 200 to 1,500 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[d,g] | 630,000 | – | 470,800 | – | 470,800 | 29,900 | – | 29,900 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Marie Lake drainage basin include a capital cost over the period of 1975-2000 of $948,000, an average annual operation and maintenance cost of $7,100, and a total 50-year present worth cost of $1,892,500.*

[c] *Cost estimated to control erosion from the estimated 18 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[e] *Cost estimated to aerate the entire hypolimnion of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[g] *The costs of sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

worth cost of these nonpoint source control measures is $821,500, with an equivalent annual cost of $52,300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,000 for nutrient inactivation to $630,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $3,700 for nutrient inactivation to $470,800 for sediment covering.

North Lake

North Lake is an 191-acre lake located in the Town of Sugar Creek in Walworth County. Certain geomorphological characteristics of North Lake are set forth in Table C-88, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-30 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality management plan. The delineated tributary drainage area should be refined in a more detailed local lake study. As shown on Map C-30, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 208 privately owned onsite sewage disposal systems—49 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-89, all sources combined contribute about 10,000 pounds of phosphorus annually to North Lake. The major source of phosphorus in the lake watershed is livestock operations. Also as indicated in Table C-89, land uses and phosphorus loadings in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.32 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a recreational use, warmwater fishery and aquatic life classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in

## Table C-88

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF NORTH LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 191 acres |
| Direct Tributary Drainage Area | 9,131 acres |
| Shoreline | 4.80 miles |
| Depth | |
| Maximum | 2.8 feet |
| Mean | 2.0 feet |
| Volume | 382 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 672 persons |
| General Existing Water Quality Conditions: | Excessive macrophyte growth; frequent fish winterkill; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.23 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-89

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO NORTH LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 202 | 49 | 0.5 | 202 | 49 | 0.5 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 49 | 142 | 1.4 | 49 | 142 | 1.4 |
| Rural Land Cover (acres) | 8,929 | 935 | 9.3 | 8,929 | 935 | 9.3 |
| Livestock Operations (animal units) | 1,335 | 8,811 | 87.8 | 1,335 | 8,811 | 87.8 |
| Atmospheric Contribution (acres of receiving surface water) | 191 | 96 | 1.0 | 191 | 96 | 1.0 |
| Total | – | 10,033 | 100.0 | – | 10,033 | 100.0 |

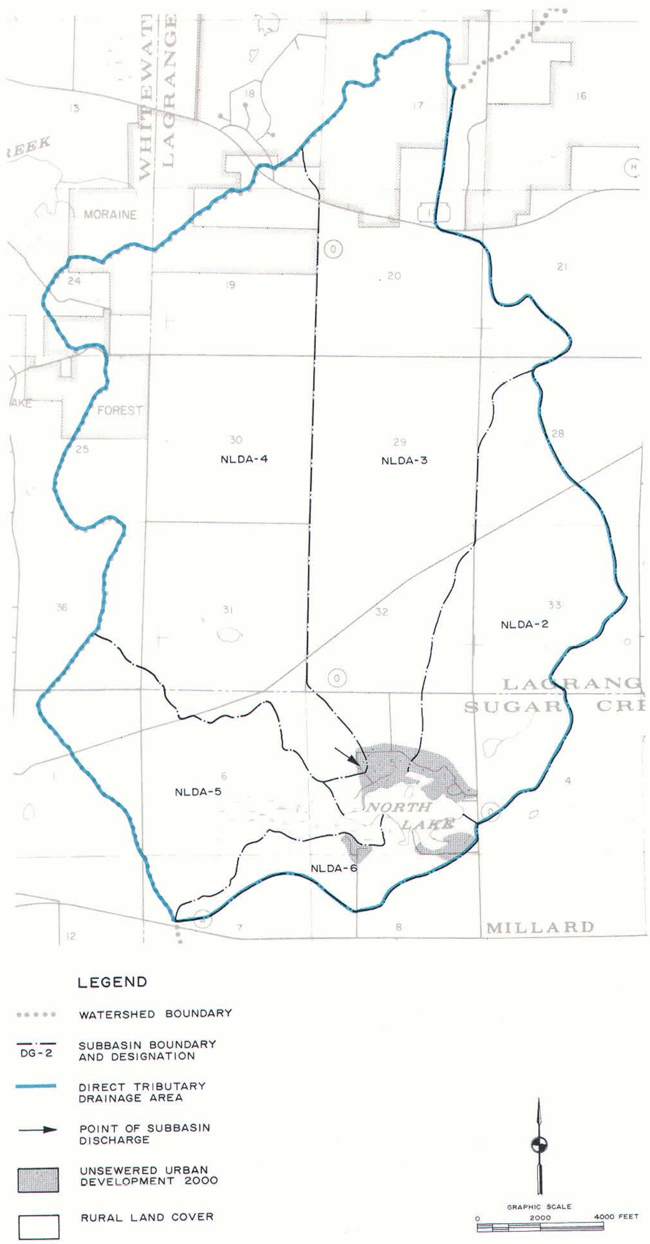
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Map C-30

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBURARY DRAINAGE AREA OF NORTH LAKE: 2000




North Lake has a direct tributary drainage area of about 9,131 acres. About 8,929 acres, or 98 percent of the drainage area, are planned to be in rural land cover, and 202 acres, or 2 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 95 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

North Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-90, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, measures to reduce pollutant runoff from rural lands by 50 percent, and low-cost measures to reduce pollutant runoff from urban lands.

Even if nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will probably provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. The application of lake restoration or rehabilitation procedures could be considered, in addition to the above nonpoint source controls. Alternative restoration measures, as set forth in Table C-90, may include sediment covering, aeration, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in North Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to North Lake would entail a total capital cost of about $208,600, and an average annual operation and maintenance cost of about $41,600. The total 50-year present worth cost of these nonpoint source control measures is $659,800, with an equivalent annual cost of $41,800. If,

Table C-90

WATER QUALITY MANAGEMENT MEASURES FOR NORTH LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 90 |
| Livestock Waste Control | $ 117,500 | $ 10,000 | $ 87,800 | $ 117,900 | $ 205,700 | $ 5,600 | $ 7,500 | $ 13,100 | | |
| Rural Conservation Practices[b] | 91,100 | 31,300 | 67,900 | 381,300 | 449,200 | 4,300 | 24,200 | 28,500 | | |
| Low Cost Urban Land Management Practices | — | 300 | — | 4,900 | 4,900 | — | 300 | 300 | | |
| Total | 208,600 | 41,600 | 155,700 | 504,100 | 659,800 | 9,900 | 32,000 | 41,900 | | |
| Macrophyte Harvesting[c] | 139,800 | 19,500 | 104,500 | 307,400 | 411,900 | 6,600 | 19,500 | 26,100 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[d] | 10,000 | 300 | 7,500 | 4,700 | 12,200 | 500 | 300 | 800 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[e,g] | 382,000 | — | 285,500 | — | 285,500 | 18,100 | — | 18,100 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 4,005,100 | — | 2,993,000 | — | 2,993,000 | 189,900 | — | 189,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of North Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the North Lake drainage basin include a capital cost over the period of 1975-2000 of $220,500, an average annual operation and maintenance cost of $6,700, and a total 50-year present worth cost* of $350,900.

[b] *Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 150 acres of North Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate 50 acres of the lake.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 2.0 feet.*

[g] *The costs of sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $10,000 for aeration to $4,005,100 for dredging. The total present worth costs of lake rehabilitation techniques would range from $12,200 for aeration to $2,993,000 for dredging.

Pell Lake

Pell Lake is an 86-acre lake located in the Town of Bloomfield in Walworth County. The lake drains to the North Branch of Nippersink Creek. Certain geomorphological characteristics of Pell Lake are set forth in Table C-91, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-31 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-31, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 714 privately owned onsite sewage disposal systems—54 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-92, all sources combined contribute about 360 pounds of phosphorus annually to Pell Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also as indicated in Table C-92, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loading and lake and drainage basin characteristics, is 0.04 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a recreational use and warmwater fishery and aquatic life classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Pell Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake was made, and a set of recommended measures was identified. These measures are set forth in Table C-93, along with the associated costs and anticipated

Table C-91

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PELL LAKE

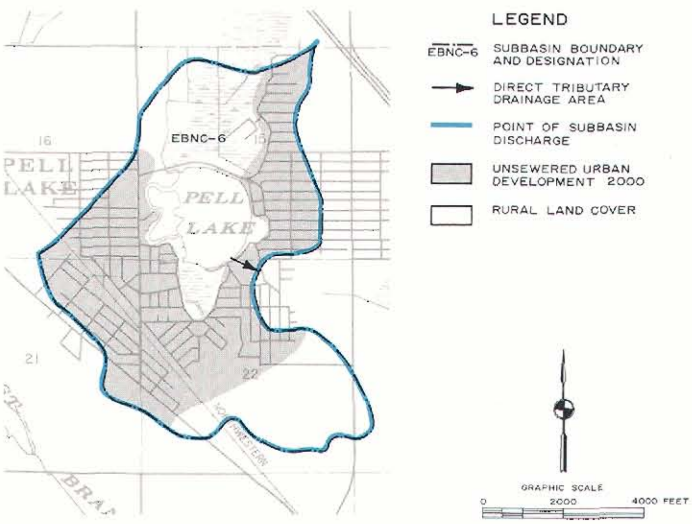
| Characteristic | Description |
|---|---|
| Surface Area . . . . . . . . . . . . | 86 acres |
| Direct Tributary Drainage Area . . . . . . . . . . . . . . . . | 1,011 acres |
| Shoreline . . . . . . . . . . . . . . | 1.8 miles |
| Depth | |
| Maximum . . . . . . . . . . . | 13 feet |
| Mean . . . . . . . . . . . . . . . | 3.6 feet |
| Volume . . . . . . . . . . . . . . . | 314 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] . . . . . | 2,142 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; fish winterkills; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.00 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-31

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PELL LAKE: 2000




Pell Lake has a direct tributary drainage area of about 1,011 acres. About 481 acres, or 48 percent of the drainage area, are planned to be in rural land cover, and 530 acres, or 52 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 50 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

## Table C-92

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PELL LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 530 | 104 | 28.7 | 530 | 104 | 28.7 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 54 | 156 | 43.1 | 54 | 156 | 43.1 |
| Rural Land Cover (acres) | 481 | 59 | 16.3 | 481 | 59 | 16.3 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 86 | 43 | 11.9 | 86 | 43 | 11.9 |
| Total | – | 362 | 100.0 | – | 362 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

effectiveness. Measures to control the phosphorus contribution include: improved septic tank management, measures to reduce pollutant runoff from rural lands by 50 percent, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above point and nonpoint source controls. Alternative restoration measures as set forth in Table C-93 may include sediment covering, aeration, and nutrient inactivation. Dredging the lake could reduce macrophyte growth through nutrient removal and deepening. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control

## Table C-93

## WATER QUALITY MANAGEMENT MEASURES FOR PELL LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 50 |
| Rural Conservation Practices[b] | $ 4,900 | $ 1,700 | $ 3,700 | $ 20,500 | $ 24,200 | $ 200 | $ 1,300 | $ 1,500 | | |
| Low Cost Urban Land Management Practices | – | 900 | – | 22,000 | 22,000 | – | 1,400 | 1,400 | | |
| Total | 4,900 | 2,600 | 3,700 | 42,500 | 46,200 | 200 | 2,700 | 2,900 | | |
| Macrophyte Harvesting[c] | 41,900 | 5,900 | 31,300 | 93,000 | 124,300 | 2,000 | 5,900 | 7,900 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[d] | 6,000 | 200 | 4,500 | 2,800 | 7,300 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[e] | 8,600 | – | 6,400 | – | 6,400 | 400 | – | 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,h] | 172,000 | – | 128,500 | – | 128,500 | 8,200 | – | 8,200 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 1,580,100 | – | 1,181,800 | – | 1,181,800 | 75,000 | – | 75,000 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Pell Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Pell Lake drainage basin include a capital cost over the period of 1975-2000 of $243,000, an average annual operation and maintenance cost of $398,200, and a total 50-year present worth cost of $870,000.*

[b] *Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 45 acres of Pell Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate 30 acres of the lake.*

[e] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 3.6 feet.*

[h] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Pell Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Pell Lake would entail a total capital cost of about $4,900, and an average annual operation and maintenance cost of about $2,600. The total 50-year present worth cost of these nonpoint source control measures is $46,200, with an equivalent annual cost of $2,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $6,000 for aeration to $1,580,100 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $6,400 for nutrient inactivation to $1,181,800 for dredging.

Peters Lake

Peters Lake is a 64-acre lake located in the Town of Troy in Walworth County. Certain geomorphological characteristics of Peters Lake are set forth in Table C-94, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-32 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-32, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 51 privately owned onsite sewage disposal systems—all located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation.

As indicated in Table C-95, all sources combined contribute about 761 pounds of phosphorus annually to Peters Lake. The major sources of phosphorus in the lake watershed are septic systems and runoff from livestock operations. Also, as indicated in Table C-95, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from septic systems and livestock runoff may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics,

Table C-94

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PETERS LAKE

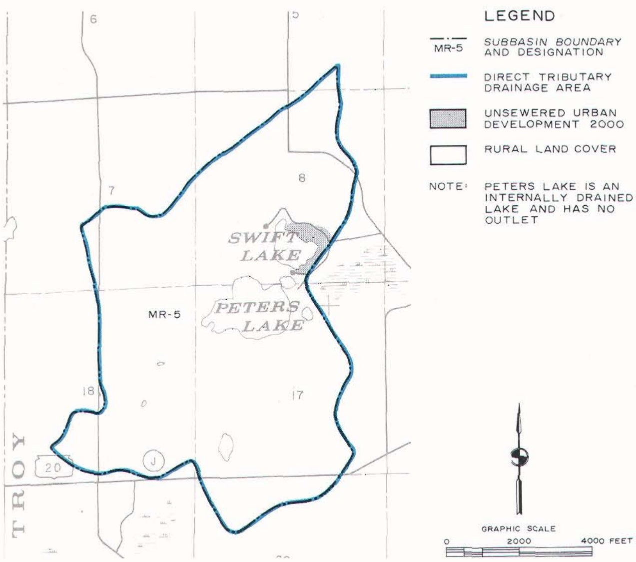
| Characteristic | Description |
|---|---|
| Surface Area | 64 acres |
| Direct Tributary Drainage Area | 1,295 acres |
| Shoreline | 1.51 miles |
| Depth | |
| Maximum | 8 feet |
| Mean | 3 feet |
| Volume | 215 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 174 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; high nutrient concentrations; oxygen depletion producing winter fishkills nearly every year |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.42 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-32

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PETERS LAKE: 2000




Peters Lake has a direct tributary drainage area of about 1,295 acres. About 1,208 acres, or 93 percent of the drainage area, are planned to be in rural land cover, and 87 acres, or 7 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 75 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

## Table C-95

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PETERS LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 87 | 9 | 1.3 | 87 | 9 | 1.3 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 51 | 148 | 19.4 | 51 | 148 | 19.4 |
| Rural Land Cover (acres) | 1,208 | 143 | 18.7 | 1,208 | 143 | 18.7 |
| Livestock Operations (animal units) | 65 | 429 | 55.2 | 65 | 429 | 55.2 |
| Atmospheric Contribution (acres of receiving surface water) | 64 | 32 | 5.4 | 64 | 32 | 5.4 |
| Total | – | 761 | 100.0 | – | 761 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

is 0.08 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings result in total phosphorus concentrations in Peters Lake which slightly exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-96, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural

## Table C-96

### WATER QUALITY MANAGEMENT MEASURES FOR PETERS LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 5,700 | $ 500 | $ 4,300 | $ 5,700 | $ 10,000 | $ 300 | $ 400 | $ 700 | | |
| Minimum Rural Conservation Practices | 200 | 2,100 | 200 | 25,800 | 26,000 | <100 | 1,600 | 1,700 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 2,100 | 2,100 | Minimal | 100 | 100 | | |
| Total | 5,900 | 2,700 | 4,500 | 33,600 | 38,100 | 400 | 2,100 | 2,500 | | 80 |
| Macrophyte Harvesting[b] | 46,600 | 6,500 | 34,800 | 102,500 | 137,300 | 2,200 | 6,500 | 8,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[c] | 6,000 | 200 | 4,500 | 3,200 | 7,700 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 6,400 | – | 4,800 | – | 4,800 | 300 | – | 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,g] | 128,000 | – | 95,700 | – | 95,700 | 6,100 | – | 6,100 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 1,238,800 | – | 925,700 | – | 925,700 | 58,700 | – | 58,700 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Peters Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Peters Lake drainage basin include a capital cost over the period of 1975-2000 of $229,500, an average annual operation and maintenance cost of $2,000, and a total 50-year present worth cost of $200,200.*

[b] *Cost estimated to harvest macrophytes from the 50 acres of Peters Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate 30 acres of the lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 3.0 feet.*

[g] *The costs of sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-96 would include dredging, aeration, sediment covering, and nutrient inactivation. The feasibility of these measues would have to be assessed in more detailed preliminary engineering studies. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized that the long-term maintenance of water quality in Peters Lake, however, requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient input to Peters Lake would entail a total capital cost over the 1980-2000 plan design period of $5,900, and an average annual operation and maintenance cost of $2,700. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $38,100, with an equivalent annual cost of $2,300. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $6,000 for aeration to $1,238,800 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,800 for nutrient inactivation to $925,700 for dredging.

Table C-97

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PEWAUKEE LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 2,493 acres |
| Direct Tributary Drainage Area | 14,819 acres |
| Shoreline | 13.7 miles |
| Depth | |
| Maximum | 45.0 feet |
| Mean | 10.0 feet |
| Volume | 24,930 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 9,314 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; high nutrient concentrations; lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated bv assuming an average of 3.68 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

<u>Pewaukee Lake</u>

Pewaukee Lake is a 2,493-acre lake located in the Town of Delafield and Pewaukee in Waukesha County. The lake drains to the Pewaukee River. Certain geomorphological characteristics of Pewaukee Lake are set forth in Table C-97, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-33 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-33, a portion of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000.[9,10] As of 1975, an estimated 2,065 privately owned onsite sewage disposal systems—826 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. In addition, the studies associated with the installation of sanitary sewers during the period 1975-1978 indicated that up to 40 percent of the septic tanks provided virtually no soil filtration capability because of improper location, installation, and operation and maintenance.

Table C-98

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PEWAUKEE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 4,380 | 2,808 | 18.3 | 6,528 | 4,268 | 28.7 |
| Land under Development–Construction Activities (acres) | 141 | 3,094 | 20.1 | 141 | 3,094 | 20.8 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 826 | 2,391 | 15.5 | 278 | 804 | 5.4 |
| Rural Land Cover (acres) | 10,298 | 1,677 | 10.9 | 8,150 | 1,316 | 8.8 |
| Livestock Operations (animal units) | 1,488 | 4,797 | 31.2 | 1,488 | 4,797 | 32.2 |
| Atmospheric Contribution (acres of receiving surface water) | 2,493 | 611 | 4.0 | 2,493 | 611 | 4.1 |
| Total | – | 15,378 | 100.0 | – | 14,890 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

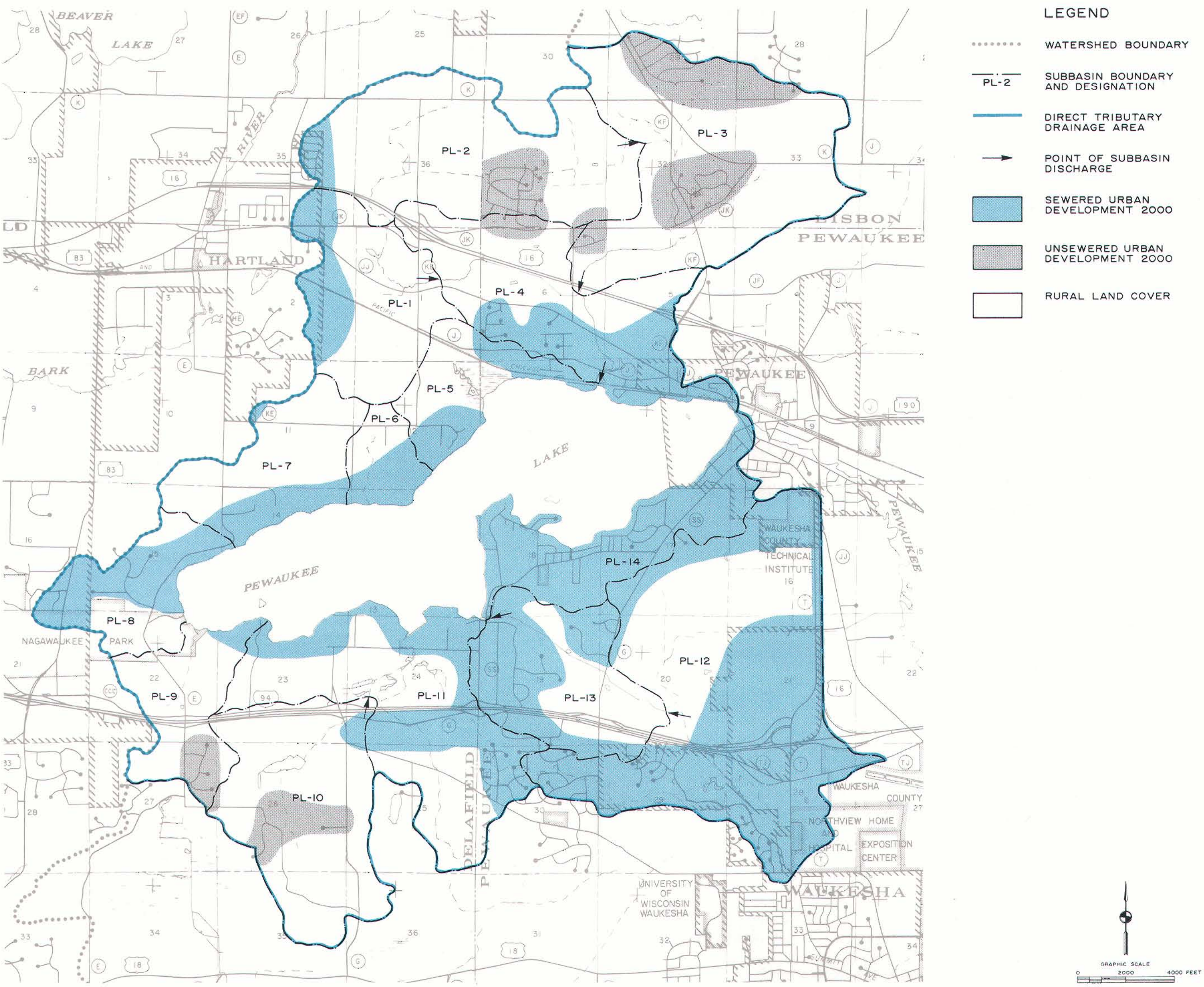
[9]*See separately published SEWRPC Community Assistance Planning Report on Water Quality Management for Pewaukee Lake, Waukesha County for a more detailed discussion of the findings and recommendations of the detailed field study.*

[10]*<u>Report on Pewaukee Lake, National Eutrophication Survey</u>, U.S. Environmental Protection Agency, July 1975.*

As indicated in Table C-98, all sources combined contribute an estimated 15,400 pounds of phosphorus annually to Pewaukee Lake during an average year of precipitation. These pollutant loads were estimated based on data developed during detailed field studies—conducted during a period of below average precipitation—interpreted against pollutant source loading estimates for the lake watershed for average or typical year conditions. Also, as indicated in Table C-98, urban land uses in the watershed are expected to increase by about 50 percent under planned year 2000 land cover conditions. However, phosphorus loadings are expected to decrease to about 14,900 pounds per year as a result of the provision of sanitary sewers. The observed total phosphorus concentration during study year 1976 spring overturn was 0.04 milligram per liter (mg/l), which is representative of a dry year condition. The water quality simulation analyses indicated that, during a year of average precipitation, the spring phosphorus concentration would approximate 0.09 mg/l under both existing and anticipated year 2000 conditions. The Commission recommends a level of 0.02 mg/l or less of total phos-

Map C-33

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PEWAUKEE LAKE: 2000




Pewaukee Lake has a direct tributary drainage area of about 14,819 acres. About 8,150 acres, or 56 percent of the drainage area, are planned to be in rural land cover, and 699'9 acres, or 44 percent, to be in urban land cover. Over the planning period an average of about 141 acres may be expected to be converted annually to urban land cover. It is estimated that a 75 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and urban management practices—including low-cost urban practices, construction erosion controls, proper septic tank system management based on a site-by-site inspection and maintenance program, and additional urban practices.

*Source: SEWRPC.*

phorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Pewaukee Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-99, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic system tank management, measures to reduce pollutant runoff from rural lands by 75 percent, low-cost measures to reduce pollutant runoff from urban lands, measures to reduce pollutant runoff from urban lands by 50 percent, and construction erosion control practices.

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. When this problem is confirmed through further local study, the specific lake restoration or rehabilitation procedures which are appropriate should be identified for application after implementation of above-mentioned point and nonpoint

Table C-99

WATER QUALITY MANAGEMENT MEASURES FOR PEWAUKEE LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Services[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 247,500 | $ 19,000 | $ 185,100 | $ 223,300 | $ 408,400 | $ 11,800 | $ 14,200 | $ 26,000 | | |
| Rural Conservation Practices[d] | 1,102,800 | 143,600 | 928,600 | 722,800 | 1,651,400 | 58,900 | 45,900 | 104,800 | | |
| Construction Erosion Control Practices[e] | 6,514,200 | 56,400 | 4,889,300 | 889,000 | 5,778,300 | 310,200 | 56,400 | 366,600 | | |
| Low Cost Urban Land Management Practices | Minimal | 8,900 | Minimal | 132,000 | 132,000 | Minimal | 8,400 | 8,400 | | 75 |
| Additional Urban Land Management Practices[f] | 187,200 | 95,800 | 133,100 | 1,124,000 | 1,257,100 | 8,400 | 71,300 | 79,800 | | |
| Total | 8,051,700 | 323,700 | 6,136,100 | 3,091,100 | 9,227,200 | 389,300 | 196,200 | 585,600 | | |
| Macrophyte Harvesting[g] | 100,000 | 45,000 | 74,700 | 709,300 | 784,000 | 4,700 | 45,000 | 49,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Water Level Management | Minimal | | Minimal | | | Minimal | | | Minimize shore erosin consolidation of sediment | No additional reduction |
| Nutrient Inactivation[h] | 57,300 to 249,300 | – | 42,800 to 186,300 | – | 186,300 | 2,700 to 11,800 | – | 2,700 to 11,800 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body. | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Upper Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Upper Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up operation and maintenance in the Pewaukee Lake drainage basin include a capital cost over the period of 1975-2000 of $11,532,000, an average annual operation and maintenance cost of $100,500, and a total 50-year present worth cost of $8,044,900.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Pewaukee Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Pewaukee Lake drainage basin include a capital cost over the period of 1975-2000 of $1,251,000, an average annual operation and maintenance cost of $25,600, and a total 50-year present worth cost of $1,572,100.*

[d] *Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads. Include minimum rural non point source controls.*

[e] *Cost estimated to control erosion from the estimated 141 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[f] *Urban land management practices necessary to achieve a 50 percent reduction in urban diffuse source pollutant loads.*

[g] *Cost estimated to harvest macrophytes from the 750 acres of Pewaukee Lake subject to excessive macrophyte growth.*

[h] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

*Source: SEWRPC.*

source controls. In addition to continued weed harvesting and fish harvesting (namely, fishing activity), alternative restoration measures as set forth in Table C-99 may include water level management and nutrient inactivation. Chemical treatment to control algae can be used if necessary, but only as a temporary solution to the problem. The feasibility of these measures would have to be assessed based on further study. It should be emphasized, however, that the long-term maintenance of water quality in Pewaukee Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Pewaukee Lake would entail a total capital cost of about $8,051,700, and an average annual operation and maintenance cost of about $323,700. The total 50-year present worth cost of these nonpoint source control measures is $9,227,200, with an equivalent annual cost of $585,600. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would be minimal for water level management to $249,300 for nutrient inactivation. The total present worth costs of lake rehabilitation techniques would be minimal for water level management to $186,300 for nutrient inactivation.

Pleasant Lake

Pleasant Lake is a 154-acre lake located in the Town of LaGrange in Walworth County. The lake is internally drained. Certain geomorphological characteristics of Pleasant Lake are set forth in Table C-100, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-34 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-34 none of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 53 privately owned onsite sewage disposal systems—44 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-101, all sources combined contribute about 300 pounds of phosphorus annually to Pleasant Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also, as indicated in Table C-101, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land use conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Pleasant Lake equal to the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table

### Table C-100

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PLEASANT LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 154 acres |
| Direct Tributary Drainage Area | 1,216 acres |
| Shoreline | 2.70 miles |
| Depth | |
| Maximum | 29 feet |
| Mean | 12.5 feet |
| Volume | 1,910 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 166 persons |
| General Existing Water Quality Conditions: | Lake water quality is generally good, though oxygen levels in the hypolimnion are occasionally low |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Table C-101

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PLEASANT LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 200 | 14 | 4.4 | 200 | 14 | 4.4 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 44 | 127 | 39.9 | 44 | 127 | 39.9 |
| Rural Land Cover (acres) | 1,016 | 100 | 31.5 | 1,016 | 100 | 31.5 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 154 | 77 | 24.2 | 154 | 77 | 24.2 |
| Total | – | 318 | 100.0 | – | 318 | 100.0 |

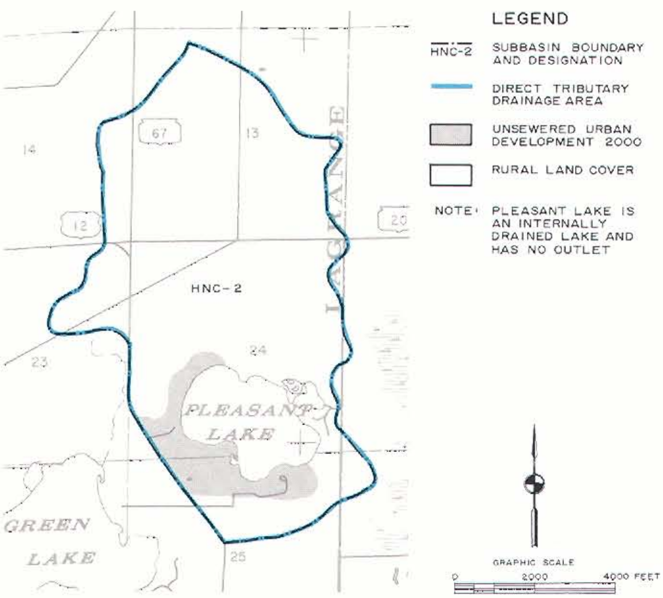
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-34

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PLEASANT LAKE: 2000




Pleasant Lake has a direct tributary drainage area of about 1,216 acres. About 1,016 acres, or 84 percent of the drainage area, are planned to be in rural land cover, and 200 acres, or 16 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

C-102, along with the associated costs and anticipated effectiveness. Measures to control the phosphorus contribution include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

Although the existing available water quality data do not indicate a need for in-lake treatment, the sediments which have been previously deposited on the lake bottom, particularly in the bay, may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures, as set forth in Table C-102, may include nutrient inactivation hypolimnetic aeration, and localized dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as macrophyte harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in lakes requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Pleasant Lake would entail a total capital cost of about \$200 and an average annual operation and maintenance cost of about \$2,100. The total 50-year present worth cost of these nonpoint source control measures is \$3,800, with an equivalent annual cost of \$2,000. If, in addition, rehabilitation techniques are found necessary, the capital cost of these nonpoint source control measures is \$26,300, with an equivalent annual cost of \$1,800. If, in addition, present worth costs of lake rehabilitation techniques would be \$9,000 for hypolimnetic aeration to \$464,100 for dredging.

Potter Lake

Potter Lake is a 162-acre lake located in the Town of East Troy in Walworth County. The lake drains to Honey Creek via an intermittently flowing ditch. Certain geomorphological characteristics of Potter Lake are set forth in Table C-103 together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-35 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-35, all of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 239 privately owned onsite sewage disposal systems—47 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-104, all sources combined contribute about 300 pounds of phosphorus annually to Potter Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also as indicated in Table C-104, urban land uses in the watershed are expected to increase by about 60 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to increase to about 500 pounds due to increased urban development. Loadings from the construction activities needed for the development of urban land are expected to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.02 milligram per liter (mg/l) and 0.04 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Potter Lake which meet and exceed the recommended level for recreational use and for the maintenance of a warmwater fishery, respectively.

## Table C-102

## WATER QUALITY MANAGEMENT MEASURES FOR PLEASANT LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 50 |
| Minimum Rural Conservavion Practices | $ 200 | $ 2,000 | $ 200 | $ 25,000 | $ 25,200 | $ <100 | $ 1,600 | $ 1,700 | | |
| Low Cost Urban Land Management Practices | – | 100 | – | 1,100 | 1,100 | – | 100 | 100 | | |
| Total | 200 | 2,100 | 200 | 26,100 | 26,300 | 100 | 1,700 | 1,800 | | |
| Macrophyte Harvesting[b] | 14,000 | 2,000 | 10,500 | 31,500 | 42,000 | 700 | 2,000 | 2,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 7,700 | 200 | 5,800 | 3,200 | 9,000 | 400 | 200 | 600 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 15,400 | – | 11,500 | – | 11,500 | 700 | – | 700 | Accelerate lake improvement; prevent release of nutrients from sediment, remove nutrients from water body | No additional reduction |
| Dredging[e,f] | 621,000 | – | 464,100 | – | 464,100 | 29,400 | – | 29,400 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Pleasant Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Pleasant Lake drainage basin include a capital cost over the period of 1975-2000 of $198,000, an average annual operation and maintenance cost of $2,100, and a total 50-year present worth cost of $181,700.*

[b] *Cost estimated to harvest macrophytes from the 15 acres of Pleasant Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 12.5 feet.*

[f] *The costs for dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged.*

*Source: SEWRPC.*

## Table C-103

## GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF POTTER LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 162 acres |
| Direct Tributary Drainage Area | 380 acres |
| Shoreline | 2.2 miles |
| Depth | |
| Maximum | 26 feet |
| Mean | 8 feet |
| Volume | 1,296 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 817 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; macrophyte growth; low oxygen concentrations in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.42 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-104

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO POTTER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 233 | 76 | 22.8 | 372 | 91 | 17.4 |
| Land under Development–Construction Activities (acres) | – | – | – | 8 | 351 | 67.1 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 47 | 136 | 40.9 | – | – | – |
| Rural Land Cover (acres) | 147 | 40 | 12.0 | – | – | – |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 162 | 81 | 24.3 | 162 | 81 | 15.5 |
| Total | – | 333 | 100.0 | – | 523 | 100.0 |

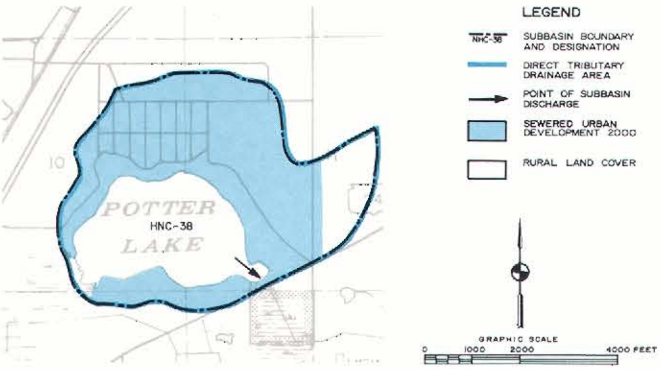
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Map C-35

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF POTTER LAKE: 2000




Potter Lake has a direct tributary drainage area of about 380 acres. None of the land in the drainage area is planned to be in rural land cover, with the entire drainage area expected to be in urban land cover. Over the planning period an average of about eight acres may be expected to be converted annually to urban land cover. It is estimated that a 50 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through minimum urban management practices—including low-cost urban practices and construction erosion controls.

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-105, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contribution include: the provision of sanitary sewer service, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-105 may include sediment covering, hypolimnetic aeration, nutrient inactivation, or dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Potter Lake requires that the recommended level of pollutant input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Potter Lake would entail a total capital cost of about $369,600, and an average annual operation and maintenance cost of about $3,700. The total 50-year present worth cost of these nonpoint source control measures is $335,100 with an equivalent annual cost of $21,300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $900 for nutrient inactivation to $1,829,100 for dredging. The total present worth costs of lake rehabilitation techniques would range from $700 for nutrient inactivation to $1,366,400 for dredging.

### Powers Lake

Powers Lake is a 459-acre lake located in the Towns of Randall and Bloomfield in Kenosha and Walworth Counties, respectively. The lake drains to the East Branch of Nippersink Creek. Certain geomorphological characteristics of Powers Lake are set forth in Table C-106, together with approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-36 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-36, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 596 privately owned onsite sewage disposal systems—109 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-107, all sources combined contribute about 2,000 pounds of phosphorus annually to Powers Lake. The major source of phosphorus in the lake watershed is runoff from livestock operations. Also, as indicated in Table C-107, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock operations may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.05 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total

Table C-105

WATER QUALITY MANAGEMENT MEASURES FOR POTTER LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis, Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Economic Analysis, Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Construction Erosion Control Practices[c] | $ 369,600 | $ 3,200 | $ 277,400 | $ 50,400 | $ 327,800 | $ 17,600 | $ 3,200 | $ 20,800 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Low Cost Urban Land Management Practices | Minimal | 500 | Minimal | 7,300 | 7,300 | Minimal | 500 | 500 | | |
| Total | 369,600 | 3,700 | 277,400 | 57,700 | 335,100 | 17,600 | 3,700 | 21,300 | | 65 |
| Macrophyte Harvesting[d] | 14,000 | 2,000 | 10,500 | 31,500 | 42,000 | 700 | 2,000 | 2,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[e] | 1,800 | 100 | 1,300 | 1,600 | 2,900 | 100 | 100 | 200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 900 to 16,200 | – | 700 to 12,100 | – | 700 to 12,100 | <100 to 800 | – | <100 to 800 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,i] | 324,000 | – | 242,100 | – | 242,100 | 15,400 | – | 15,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[h,i] | 1,829,100 | – | 1,366,900 | – | 1,366,900 | 86,700 | – | 86,700 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Potter Lake drainage basin include a capital cost over the period of 1975-2000 of $1,592,000, an average annual operation and maintenance cost of $11,900, and a total 50-year present worth cost of $1,080,200.*

[c] *Cost estimated to control erosion from the estimated 8 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *Cost estimated to harvest macrophytes from the 15 acres of Potter Lake subject to excessive macrophyte growth.*

[e] *Cost estimated to aerate the entire hypolimnion of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 8 feet.*

[i] *The costs for sediment covering and dredging depend on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

phosphorus concentrations in Powers Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-108, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-108 may include nutrient inactivation by the addition of alum and hypolimnetic aeration. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized,

## Table C-106

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF POWERS LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 459 acres |
| Direct Tributary Drainage Area | 2,426 acres |
| Shoreline | 5.3 miles |
| Depth | |
| Maximum | 33 feet |
| Mean | 16.2 feet |
| Volume | 7,453 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,973 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms in bays; moderate nutrient concentrations; portions of hypolimnion void of dissolved oxygen at times |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-107

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO POWERS LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 493 | 95 | 4.6 | 493 | 95 | 4.6 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 109 | 316 | 15.5 | 109 | 316 | 15.5 |
| Rural Land Cover (acres) | 1,933 | 225 | 11.0 | 1,933 | 225 | 11.0 |
| Livestock Operations (animal units) | 178 | 1,174 | 57.6 | 178 | 1,174 | 57.6 |
| Atmospheric Contribution (acres of receiving surface water) | 459 | 229 | 11.3 | 459 | 229 | 11.3 |
| Total | – | 2,039 | 100.0 | – | 2,039 | 100.0 |

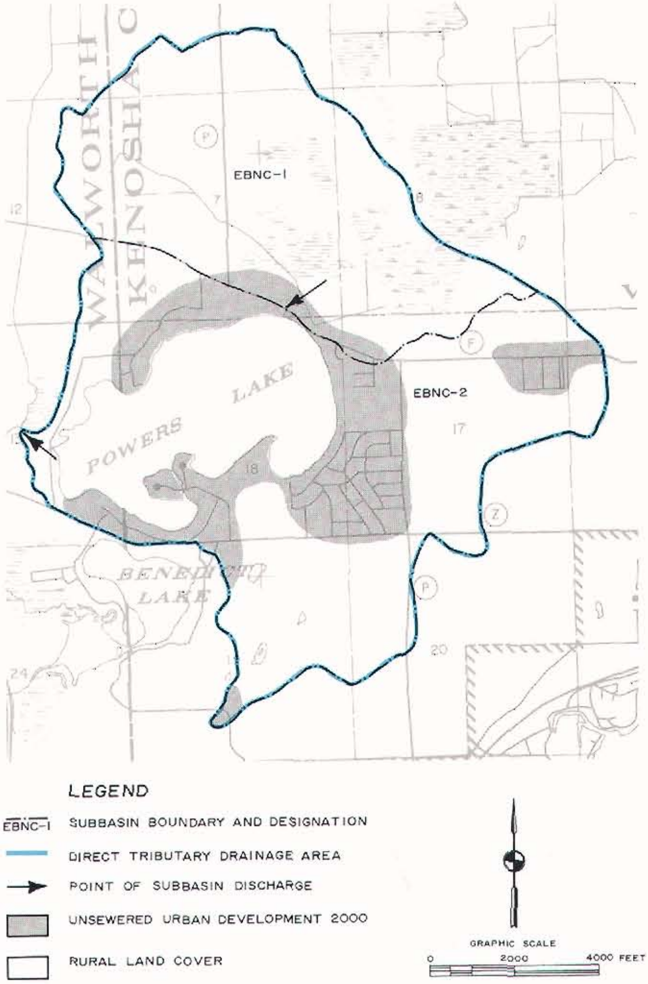
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Map C-36

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF POWERS LAKE: 2000




Powers Lake has a direct tributary drainage area of about 2,426 acres. About 1,933 acres, or 80 percent of the drainage area, are planned to be in rural land cover, and 493 acres, or 20 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-108

WATER QUALITY MANAGEMENT MEASURES FOR POWERS LAKE, KENOSHA AND WALWORTH COUNTIES

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Economic Analysis: Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 75 |
| Livestock Waste Control | $ 15,700 | $ 1,300 | $ 11,700 | $ 15,700 | $ 27,400 | $ 700 | $ 1,000 | $ 1,700 | | |
| Minimum Rural Conservation Practices | 400 | 3,400 | 300 | 41,300 | 41,600 | < 100 | 2,600 | 2,700 | | |
| Low Cost Urban Land Management Practices | Minimal | 800 | Minimal | 12,000 | 12,000 | Minimal | 800 | 800 | | |
| Total | 16,100 | 5,500 | 12,000 | 69,000 | 81,000 | 800 | 4,400 | 5,200 | | |
| Hypolimnetic Aeration[b] | 38,600 | 1,000 | 28,800 | 15,800 | 44,600 | 1,800 | 1,000 | 2,800 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[c] | 19,300 to 45,900 | -- | 14,400 to 34,300 | -- | 14,400 to 34,300 | 900 to 2,200 | -- | 900 to 2,200 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |

*[a] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Powers Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Powers Lake drainage basin include a capital cost over the period of 1975-2000 of $490,500, an average annual operation and maintenance cost of $19,000, and a total 50-year present worth cost of $913,400.*

*[b] Cost estimated to aerate the entire hypolimnion of the lake.*

*[c] The cost for nutrient inactivation is for treating only the hypolimnetic area with alum.*

*Source: SEWRPC.*

however, that the long-term maintenance of water quality in Powers Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Powers Lake would entail a total capital cost of about $16,100, and an average annual operation and maintenance cost of about $5,500. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $81,000, with an equivalent annual cost of $5,200. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $19,300 for nutrient inactivation to $38,600 for hypolimnetic aeration. The total present worth costs of lake rehabilitation techniques would range from $14,400 for nutrient inactivation to $44,600 for hypolimnetic aeration.

Saylesville Millpond

The Saylesville Millpond is a 66-acre lake located in the Town of Genesee in Waukesha County. The pond is formed by a dam on Genesee Creek tributary to the Fox River. Certain geomorphological characteristics of the lake are set forth in Table C-109, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-37 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-37, a portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 324 privately owned onsite sewage disposal

Table C-109

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SAYLESVILLE MILLPOND

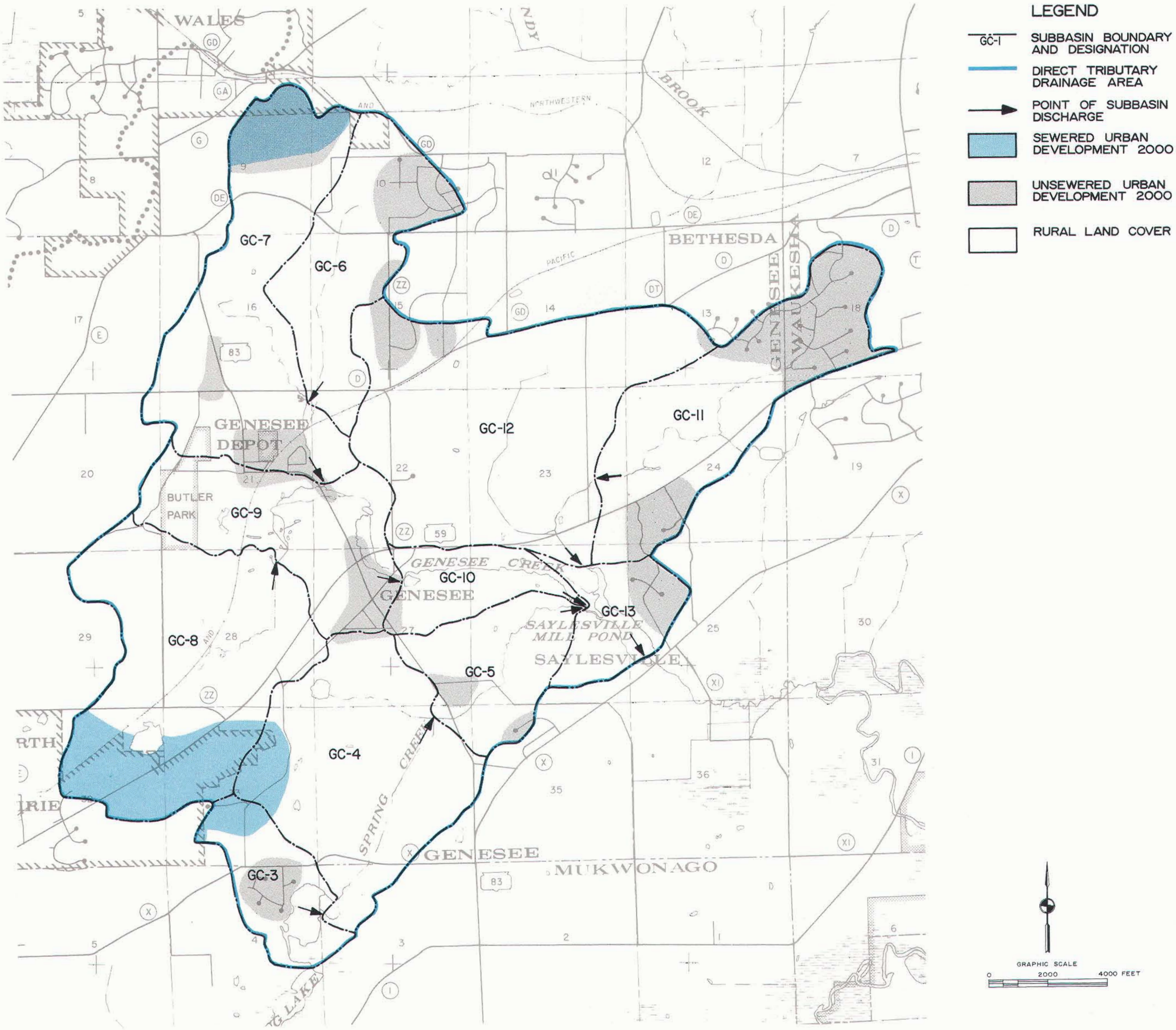
| Characteristic | Description |
|---|---|
| Surface Area | 66 acres |
| Direct Tributary Drainage Area | 8,848 acres |
| Shoreline | 2.20 miles |
| Depth: Maximum | 4.0 feet |
| Depth: Mean | 1.4 feet |
| Volume | 92.4 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,173 persons |
| General Existing Water Quality Conditions: | Little water quality data is available for the millpond, although macrophyte growth has been documented in the upper reaches of the pond. High levels of turbidity probably occur in the millpond |

*[a] The population of the direct tributary watershed is estimated by assuming an average of 3.62 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-37

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SAYLESVILLE MILLPOND: 2000




Saylesville Millpond has a direct tributary drainage area of about 8,848 acres. About 7,713 acres, or 87 percent of the drainage area, are planned to be in rural land cover, and 1,135 acres, or 13 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 95 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

systems—114 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-110, all direct sources combined contribute about 22,200 pounds of phosphorus annually to Saylesville Millpond. The major source of phosphorus in the lake watershed is livestock operations. An additional 2,900 pounds of phosphorus is annually contributed through discharges from Genesee Creek. Urban land uses in the watershed are expected to increase slightly under planned year 2000 land cover conditions. The annual phosphorus load from Genesee Creek is expected to be reduced through basic nonpoint source controls to about 1,000 pounds by the year 2000. The

## Table C-110

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SAYLESVILLE MILLPOND: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,135 | 435 | 2.0 | 1,487 | 577 | 2.5 |
| Land under Development—Construction Activities (acres) | – | – | – | -18 | 810 | 3.5 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 114 | 330 | 1.5 | 101 | 292 | 1.3 |
| Rural Land Cover (acres) | 7,713 | 817 | 3.7 | 7,343 | 778 | 3.4 |
| Livestock Operations (animal units) | 3,116 | 20,566 | 92.7 | 3,116 | 20,566 | 89.2 |
| Atmospheric Contribution (acres of receiving surface water) | 66 | 33 | 0.1 | 66 | 33 | 0.1 |
| Total | – | 22,181[c] | 100.0 | – | 23,056[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 2,900 pounds per year or the year 2000 anticipated phosphorus load of 1,000 pounds per year contirbuted by the upstream portion of Genesee Creek.*

*Source: SEWRPC.*

estimated total phosphorus concentrations during spring under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.75 milligram per liter (mg/l) and 0.71 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic macrophyte growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in the Saylesville Millpond which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-111, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, construction erosion control practices,

## Table C-111

### WATER QUALITY MANAGEMENT MEASURES FOR SAYLESVILLE MILLPOND IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 274,200 | $ 23,300 | $ 205,100 | $ 275,100 | $ 480,200 | $ 13,000 | $ 17,400 | $ 30,400 | | |
| Rural Conservation Practices[b] | 78,700 | 27,000 | 58,600 | 329,400 | 388,000 | 3,700 | 20,800 | 24,500 | | 95 |
| Construction Erosion Control Practices | 814,000 | 7,400 | 611,000 | 116,600 | 727,600 | 38,800 | 7,400 | 46,200 | | |
| Low Cost Urban Land Management Practices | – | 1,800 | – | 27,700 | 27,700 | – | 1,700 | 1,700 | | |
| Total | 1,166,900 | 59,500 | 874,700 | 748,800 | 1,623,500 | 55,500 | 46,400 | 101,900 | | |
| Macrophyte Harvesting[c] | 9,300 | 1,300 | 7,000 | 20,500 | 27,500 | 400 | 1,300 | 1,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Sediment Covering[d,f] | 132,000 | – | 98,600 | – | 98,600 | 6,300 | – | 6,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[e,f] | 1,447,800 | – | 1,081,200 | – | 1,081,200 | 68,600 | – | 68,600 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of the Saylesville Millpond. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Saylesville Millpond drainage basin include a capital cost over the period of 1975-2000 of $451,000, an average annual operation and maintenance cost of $10,700, and a total 50-year present worth cost of $617,000.*

[b] *Rural land management practice necessary to achieve a 50 percent reduction in rural nonpoint source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 10 acres of Saylesville Millpond subject to excessive macrophyte growth.*

[d] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[e] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 14 feet.*

[f] *The costs of sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material required to be dredged or filled.*

*Source: SEWRPC.*

measures to reduce pollutant runoff from rural lands by 50 percent, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-111 may include sediment covering and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Saylesville Millpond requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control management measures to control the nutrient inputs to Saylesville Millpond would entail a total capital cost of about $1,166,900, and an average annual operation and maintenance cost of about $59,500. The total 50-year present worth cost of these nonpoint source control measures is $1,623,500, with an equivalent annual cost of $101,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $132,000 for sediment covering to $1,447,800 for dredging. The total present worth costs of lake rehabilitation techniques would range from $98,600 for sediment covering to $1,081,200 for dredging.

Silver Lake

Silver Lake is a 464-acre lake located in the Town of Salem in Kenosha County. The lake drains to the Fox River. Certain geomorphological characteristics of Silver Lake are set forth in Table C-112, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-38 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-38 all significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 249 privately owned onsite sewage disposal systems—64 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-113, all sources combined contribute about 2,300 pounds of phosphorus annually to Silver Lake. The major sources of phosphorus in the lake watershed are livestock operations and runoff from construction sites. Also as indicated in Table C-113, the existing urban land uses are expected to increase by about 12 percent under planned year 2000 land cover conditions. Unless reduced by the implementation of control measures, phosphorus loadings from livestock operations and construction activities may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake

**Table C-112**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SILVER LAKE, KENOSHA COUNTY**

| Characteristic | Description |
|---|---|
| Surface Area | 464 acres |
| Direct Tributary Drainage Area | 3,191 acres |
| Shoreline | 4.10 miles |
| Depth | |
| Maximum | 44 feet |
| Mean | 10 feet |
| Volume | 4,819 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,238 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

**Table C-113**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SILVER LAKE, KENOSHA COUNTY**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 462 | 150 | 6.5 | 518 | 168 | 7.8 |
| Land under Development—Construction Activities (acres) | 9.5 | 426 | 18.6 | 9.5 | 426 | 19.7 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 64 | 185 | 8.1 | 20 | 58 | 2.7 |
| Rural Land Cover (acres) | 2,719 | 423 | 18.4 | 2,663 | 404 | 18.7 |
| Livestock Operations (animal units) | 133 | 878 | 38.3 | 133 | 878 | 40.4 |
| Atmospheric Contribution (acres of receiving surface water) | 464 | 232 | 10.1 | 464 | 232 | 10.7 |
| Total | – | 2,294 | 100.0 | – | 2,166 | 100.0 |

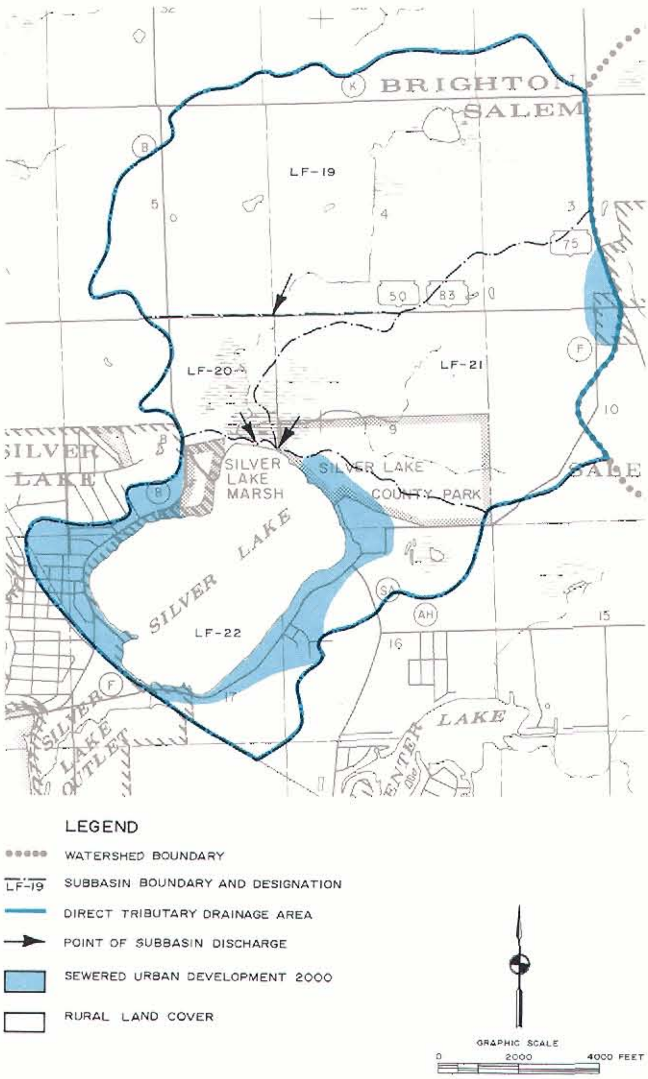
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-38

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SILVER LAKE, KENOSHA COUNTY: 2000




Silver Lake has a direct tributary drainage area of about 3,191 acres. About 2,663 acres, or 83 percent of the drainage area, are planned to be in rural land cover, and 528 acres, or 16 percent, to be in urban land cover. Over the planning period an average of about 10 acres may be expected to be converted annually to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

and drainage basin characteristics, is 0.05 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Silver Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-114, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-114 may include dredging, hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Silver Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Silver Lake would entail a total capital cost of about $451,200, and an average annual operation and maintenance cost of about $10,300. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $479,400, with an equivalent annual cost of $30,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $7,900 for nutrient inactivation to

## Table C-114

### WATER QUALITY MANAGEMENT MEASURES FOR SILVER LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 60 |
| Livestock Waste Control | $ 11,700 | $ 1,000 | $ 8,800 | $ 11,700 | $ 20,500 | $ 600 | $ 700 | $ 1,300 | | |
| Minimum Rural Conservation Practices | 600 | 4,800 | 400 | 58,200 | 58,600 | <100 | 3,700 | 3,800 | | |
| Construction Erosion Control Practices[d] | 438,900 | 3,800 | 329,400 | 59,900 | 389,300 | 20,900 | 3,800 | 24,700 | | |
| Low Cost Urban Land Management Practices | – | 700 | – | 11,000 | 11,000 | – | 700 | 700 | | |
| Total | 451,200 | 10,300 | 338,600 | 140,800 | 479,400 | 21,600 | 8,900 | 30,500 | | |
| Macrophyte Harvesting[e] | 55,900 | 7,800 | 41,800 | 12,300 | 54,100 | 2,700 | 800 | 3,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 15,800 | 400 | 11,800 | 6,300 | 18,100 | 700 | 400 | 1,100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 7,900 to 46,400 | – | 5,900 to 34,700 | – | 5,900 to 34,700 | 400 to 2,200 | – | 400 to 2,200 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,j] | 928,000 | – | 693,500 | – | 693,500 | 44,000 | – | 44,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[i,j] | 1,076,500 | – | 804,500 | – | 804,500 | 51,000 | – | 51,000 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. The estimated expenditures for local hook-up and operation and maintenance in the Silver Lake drainage basin include a capital cost over the period of 1975-2000 of $252,000, an average annual operation and maintenance cost of $5,600, and a total 50-year present worth cost of $230,100.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Silver Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Silver Lake drainage basin include a capital cost over the period of 1975-2000 of $90,000, an average annual operation and maintenance cost of $1,500, and a total 50-year present worth cost of $100,400.*

[d] *Cost estimated to control erosion from the estimated 9.5 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 60 acres of Silver Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 10 feet.*

[j] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

$1,076,500 for dredging. The total present worth costs of lake rehabilitation techniques would range from $5,900 for nutrient inactivation $804,500 for dredging.

Silver Lake

Silver Lake is an 84-acre lake located in the Town of Sugar Creek in Walworth County. The lake is a shallow, internally drained depression. Certain geomorphological characteristics of Silver Lake are set forth in Table C-115, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-39 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-39, none of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 79 privately owned onsite sewage disposal systems—10 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-116, all sources combined contribute about 120 pounds of phosphorus annually to Silver Lake. The major source of phosphorus in the lake watershed is direct atmospheric deposition on the lake surface. Also, as indicated in Table C-116, land uses and phosphorus loads in the watershed are not expected to

Table C-115

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SILVER LAKE, WALWORTH COUNTY

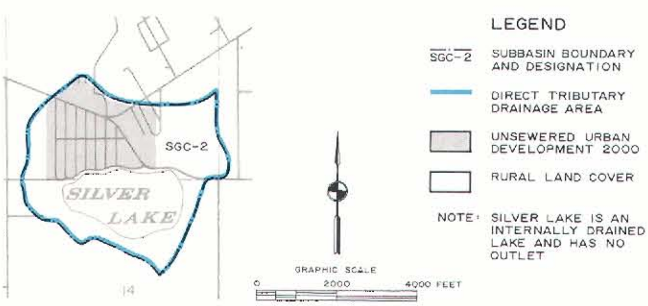
| Characteristic | Description |
|---|---|
| Surface Area | 84 acres |
| Direct Tributary Drainage Area | 270 acres |
| Shoreline | 1.5 miles |
| Depth | |
| Maximum | 3.0 feet |
| Mean | 2.8 feet |
| Volume | 211 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 255 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; locally excessive macrophyte growth; frequent fish winterkill; fluctuating water surface elevation affects water use |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.23 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-39

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SILVER LAKE, WALWORTH COUNTY: 2000




Silver Lake has a direct tributary drainage area of about 270 acres. About 162 acres, or 60 percent of the drainage area, are planned to be in rural land cover, and 108 acres, or 40 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-116

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SILVER LAKE, WALWORTH COUNTY: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 108 | 33 | 27.8 | 108 | 33 | 27.8 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 10 | 29 | 24.2 | 10 | 29 | 24.2 |
| Rural Land Cover (acres) | 162 | 15 | 12.8 | 162 | 15 | 12.8 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 84 | 42 | 35.2 | 84 | 42 | 35.2 |
| Total | – | 119 | 100.0 | – | 119 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

change significantly under planned year 2000 land cover conditions. Estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Silver Lake which meet the recommended level for recreational use and for the maintenance of a warmwater fishery. The implementation of minimum nonpoint source control measures are recommended, however, to maintain recreational use potential and encourage a more diversified aquatic community.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-117, along with the associated costs and anticipated effectiveness. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth. The application of lake restoration or rehabilitation techniques such as sediment covering, aeration, or dredging would enhance the lakes recreational use and fishery. However, the feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term

## Table C-117

## WATER QUALITY MANAGEMENT MEASURES FOR SILVER LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 30 |
| Minimum Rural Conservation Practices | $ <100 | $ 600 | $ <100 | $ 6,900 | $ 7,000 | $ 400 | $ 400 | $ 800 | | |
| Low Cost Urban Land Management Practices | – | 200 | – | 2,600 | 2,600 | – | 200 | 200 | | |
| Total | 100 | 800 | 100 | 9,500 | 9,600 | 400 | 600 | 1,000 | | |
| Aeration[b] | 4,000 | 100 | 3,000 | 1,600 | 4,600 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[c,e] | 168,000 | – | 125,500 | – | 125,500 | 8,000 | – | 8,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[d,e] | 1,653,000 | – | 1,235,300 | – | 1,235,300 | 78,400 | – | 78,400 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Silver Lake.. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Silver Lake drainage basin include a capital cost over the period of 1975-2000 of $45,000, an average annual operation and maintenance cost of $2,500, and a total 50-year present worth cost of $108,100.*

[b] *Cost estimated to aerate 20 acres of the lake.*

[c] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[d] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 2.8 feet.*

[e] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

maintenance of water quality in Silver Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint pollution control measures to control the nutrient inputs would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $800. The total 50-year present worth cost of these nonpoint source control measures is $9,600, with an equivalent annual cost of $600. If, in addition, rehabilitation techniques are fond necessary, the capital cost of these alternatives would range from $4,000 for aeration to $1,653,000 for dredging. The total present worth costs of the lake rehabilitation techniques would range from $4,600 for aeration to $1,235,300 for dredging.

### Spring Lake

Spring Lake is a 105-acre lake located in the Town of Mukwonago in Waukesha County. The lake drains to Genesee Creek. Certain geomorphological characteristics of Spring Lake are set forth in Table C-118, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-40 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-40, a portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 119 privately owned onsite sewage disposal systems—21 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-119, all sources combined contribute about 2,900 pounds of phosphorus annually to Spring Lake. The major source of phosphorus in the lake watershed is livestock operations. Also as indicated in Table C-119, urban land uses and phosphorus loads in the watershed are expected to increase slightly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.05 milligram per liter (mg/l) and .06 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total

## Table C-118

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SPRING LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 105 acres |
| Direct Tributary Drainage Area | 3,096 acres |
| Shoreline | 2.2 miles |
| Depth | |
| Maximum | 22 feet |
| Mean | 5 feet |
| Volume | 553 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 436 persons |
| General Existing Water Quality Conditions: | Good water quality; dissolved oxygen occasionally low in the hypolimnion; significant macrophyte growth in the north bay area |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.66 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

## Table C-119

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SPRING LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 319 | 35 | 1.2 | 471 | 53 | 1.6 |
| Land under Development–Construction Activities (acres) | – | – | – | 8 | 360 | 10.8 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 21 | 61 | 2.1 | 21 | 61 | 1.8 |
| Rural Land Cover (acres) | 2,777 | 271 | 9.2 | 2.617 | 260 | 8.0 |
| Livestock Operations (animal units) | 382 | 2,521 | 85.7 | 382 | 2,521 | 76.2 |
| Atmospheric Contribution (acres of receiving surface water) | 105 | 52 | 1.8 | 105 | 52 | 1.6 |
| Total | – | 2,940 | 100.0 | – | 3,307 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Table C-120

### WATER QUALITY MANAGEMENT MEASURES FOR SPRING LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential, protect public health and drinking water supplies | 80 |
| Livestock Waste Control | $ 33,600 | $ 2,900 | $ 25,100 | $ 33,700 | $ 58,800 | $ 1,600 | $ 2,100 | $ 3,700 | | |
| Minimum Rural Conservation Practices | 600 | 4,900 | 400 | 59,300 | 59,700 | <100 | 3,800 | 3,900 | | |
| Construction Erosion Control Practices | 352,000 | 3,000 | 264,200 | 47,300 | 311,500 | 16,800 | 3,000 | 19.800 | | |
| Low Cast Urban Land Management Practices | Minimal | 500 | Minimal | 7,800 | 7,800 | Minimal | 500 | 500 | | |
| Total | 386,200 | 11,300 | 289,700 | 148,100 | 437,800 | 18,500 | 9,400 | 34,300 | | |
| Macrophyte Harvesting[b] | 32,600 | 4,600 | 24,400 | 71,700 | 96,100 | 1,500 | 4,600 | 6,100 | Control excessive macrophyte growth; *aesthetic enhancement*; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 800 | <100 | 600 | <100 | 700 | <100 | <100 | 200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[d,f] | 210,000 | – | 156,900 | – | 156,900 | 10,000 | – | 10,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[e,f] | 1,693,700 | – | 1,265,700 | – | 1,265,700 | 80,300 | – | 80,300 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Spring Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Spring Lake drainage basin include a capital cost over the period of 1975-2000 of $94,500, an average annual operation and maintenance cost of $3,800, and a total 50-year present worth cost of $180,200.*

[b] *Cost estimated to harvest macrophytes from the 35 acres of Spring Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

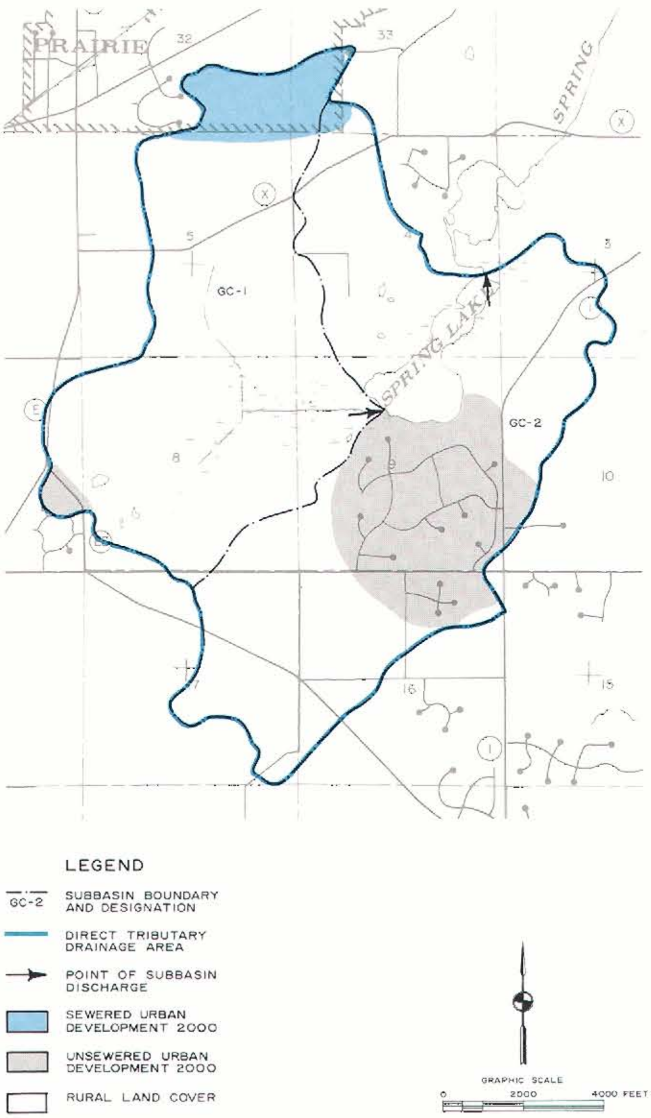
[e] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 5 feet.*

[f] *The costs for sediment covering and dredging vary widely, depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

Map C-40

PLANNED LAND COVER DEVELOPMENT
IN THE DIRECT TRIVUTARY DRAINAGE
AREA OF SPRING LAKE: 2000




Spring Lake has a direct tributary drainage area of about 3,096 acres. About 2,777 acres, or 90 percent of the drainage area, are planned to be in rural land cover, and 319 acres, or 10 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

phosphorus concentrations in Spring Lake which exceed recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-120, along with the associated costs and anticipated effectiveness. Measures to control livestock operation contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and concentration erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-120 may include sediment covering, hypolimnetic aeration, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Spring Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above - listed nonpoint source pollution control measures to control the nutrient inputs to Spring Lake would entail a total capital cost of about $386,200 and an average annual operation and maintenance cost of about $11,300. The total 50-year present worth cost of these source control measures is $437,800, with an equivalent annual cost of $34,300. If in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $800 for hypolimnetic aeration to $1,693,700 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $700 for hypolimnetic aeration to $1,265,700 for dredging.

## Upper and Lower Phantom Lakes

The Phantom Lakes are two interconnected lakes, Upper Phantom Lake and Lower Phantom Lake, with a combined surface area of 540 acres. They are located in the Town of Mukwonago in Waukesha County. The lakes are fed by and drain to the Mukwonago River. Certain geomorphological characteristics of the Phantom Lakes are

### Table C-121

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF UPPER AND LOWER PHANTOM LAKES

| Characteristic | Description |
|---|---|
| Surface Area | 540 acres |
| Direct Tributary Drainage Area | 20,178 acres |
| Shoreline | 3.91 miles |
| Depth | |
| Maximum | 29 feet |
| Mean | 5.1 feet |
| Volume | 2,750 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 4,422 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.66 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Table C-122

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO UPPER AND LOWER PHANTOM LAKES: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 3,316 | 787 | 4.6 | 3,969 | 842 | 5.0 |
| Land under Development—Construction Activities (acres) | 32 | 1,459 | 8.5 | 32 | 1,459 | 8.7 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 424 | 1,228 | 7.2 | 300 | 869 | 5.2 |
| Rural Land Cover (acres) | 16,830 | 3,840 | 22.4 | 16,179 | 3,756 | 22.5 |
| Livestock Operations (animal units) | 1,444 | 9,530 | 55.7 | 1,444 | 9,530 | 57.0 |
| Atmospheric Contribution (acres of receiving surface water) | 540 | 270 | 1.6 | 540 | 270 | 1.6 |
| Total | – | 17,144[c] | 100.0 | – | 16,726[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the estimated phosphorus load of 2,000 pounds per year as the year 2000 anticipated phosphorus load of 400 pounds per year contributed from the Mukwonago River.*

*Source: SEWRPC.*

set forth in Table C-121, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-41 presents a graphic summary of the proposed year 2000 land cover in the watershed. As shown on Map C-41 a portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 733 privately owned onsite sewage disposal systems—424 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

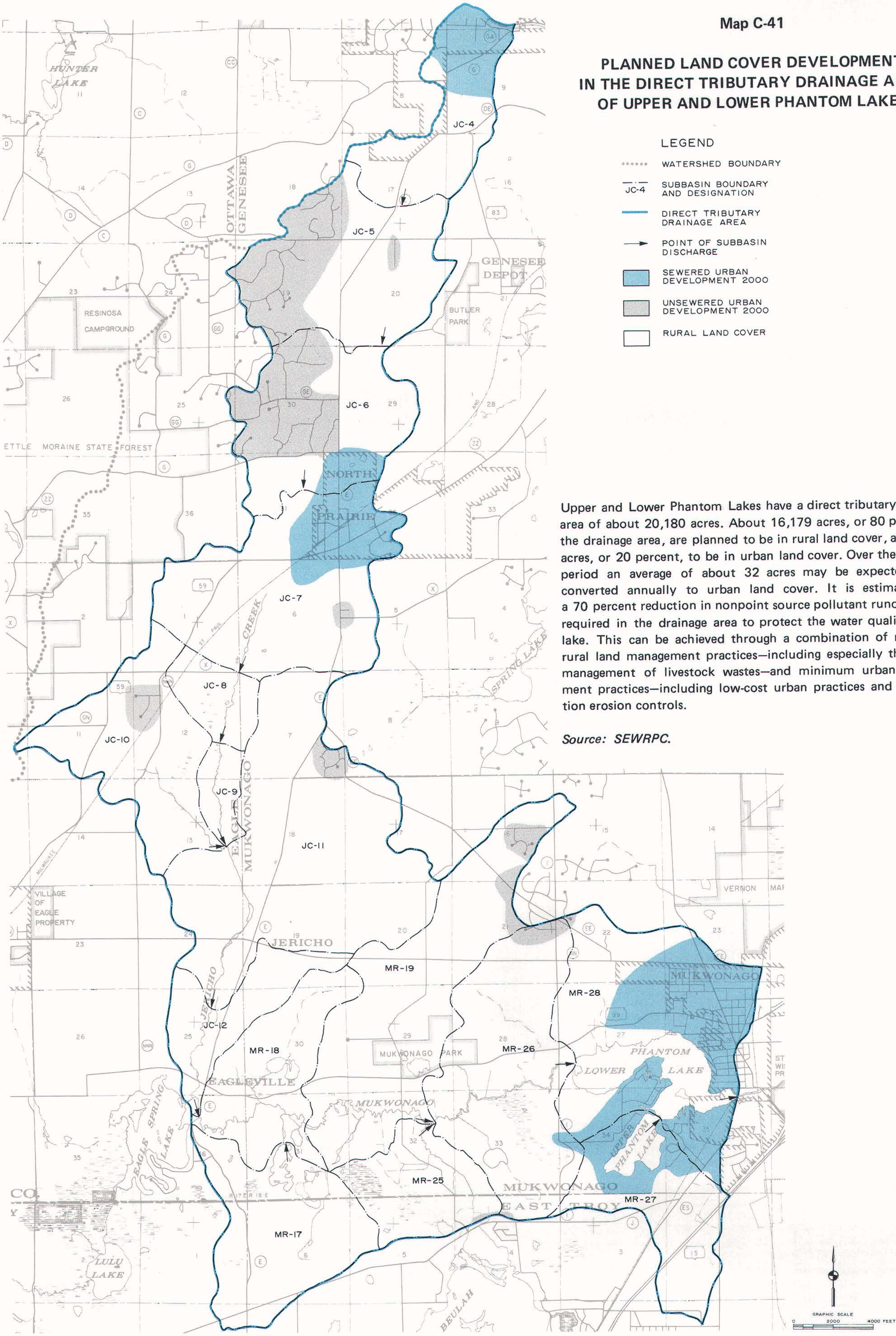
As indicated in Table C-122, all direct sources combined contribute about 17,100 pounds of phosphorus annually to the Phantom Lakes. The major source of phosphorus in the lake watershed is livestock operations. An additional 2,000 pounds of phosphorus is contributed from the Mukwonago River to the Phantom Lakes. As indicated in Table C-122, urban land uses in the watershed are expected to increase by about 20 percent under planned year 2000 land cover conditions. Annual direct total phosphorus loadings to the lakes, however, may be expected to be reduced to about 16,700 pounds as a result of the extension of the sanitary sewer service area, thereby eliminating malfunctioning septic tank systems. The phosphorus load from the Mukwonago River is expected to be reduced to about 400 pounds as a result of recommended pollution controls for those lakes. Loadings from livestock operations are expected to continue to be the primary source of phosphorus to the lake under anticipated year 2000 conditions.

The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.07 milligram per liter (mg/l) and 0.06 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in the Phantom Lakes which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading to the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-123, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic system management, minimum measures to reduce pollutant runoff from rural lands through the

## Map C-41

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF UPPER AND LOWER PHANTOM LAKES




Upper and Lower Phantom Lakes have a direct tributary drainage area of about 20,180 acres. About 16,179 acres, or 80 percent of the drainage area, are planned to be in rural land cover, and 4,001 acres, or 20 percent, to be in urban land cover. Over the planning period an average of about 32 acres may be expected to be converted annually to urban land cover. It is estimated that a 70 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and construction erosion controls.

*Source: SEWRPC.*

## Table C-123

### WATER QUALITY MANAGEMENT MEASURES FOR UPPER AND LOWER PHANTOM LAKES IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | | |
| Livestock Waste Control | $ 174,600 | $ 14,000 | $ 130,600 | $ 165,000 | $ 295,600 | $ 8,300 | $ 10,500 | $ 18,800 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 70 |
| Minimum Rural Conservation Practices | 3,500 | 30,300 | 21,000 | 369,600 | 390,600 | <100 | 23,400 | 23,500 | | |
| Construction Erosion Control Practices[d] | 1,478,400 | 12,800 | 1,109,600 | 201,800 | 1,311,400 | 70,400 | 12,800 | 83,200 | | |
| Low Cost Urban Land Management Practices | – | 4,600 | – | 68,600 | 68,600 | – | 4,400 | 4,400 | | |
| Total | 1,656,500 | 61,700 | 1,261,200 | 805,000 | 2,066,200 | 78,800 | 51,100 | 129,900 | | |
| Macrophyte Harvesting[e] | 302,900 | 42,300 | 226,400 | 666,700 | 893,100 | 14,400 | 42,300 | 56,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 2,600 | 100 | 1,900 | 2,000 | 3,900 | 100 | 100 | 200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 54,000 | – | 40,400 | – | 40,400 | 2,600 | – | 2,600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,j] | 1,080,000 | – | 807,100 | – | 807,100 | 51,200 | – | 51,200 | Accelerate lake improvement; prevent release of nutrients from sediment, reduce suitable plant substrate | No additional reduction |
| Dredging[i,j] | 8,623,000 | – | 6,444,000 | – | 6,444,000 | 408,800 | – | 408,800 | Deepen lake; reduce macrophyte growth | No additional reduction |

*[a] The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

*[b] Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Phantom Lakes drainage basin include a capital cost over the period of 1975-2000 of $2,808,000, an average annual operation and maintenance cost of $35,300, and a total 50-year present worth cost of $2,129,900.*

*[c] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Upper and Lower Phantom Lakes. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Phantom Lakes drainage basin include a capital cost over the period of 1975-2000 of $675,000, an average annual operation and maintenance cost of $27,000, and a total 50-year present worth cost of $931,800.*

*[d] Cost estimated to control erosion from the estimated 32 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*[e] Cost estimated to harvest macrophytes from the 325 acres of the Phantom Lakes subject to excessive macrophyte growth.*

*[f] Cost estimated to aerate the entire hypolimnion of the lake.*

*[g] The cost for nutrient inactivation is for treating entire lake with alum.*

*[h] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[i] Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 5.1 feet.*

*[j] The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, the type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-123 may include dredging, sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in the Phantom Lakes requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to the Phantom Lakes would entail a total capital cost of about $1,656,500 and an average annual operation and maintenance cost of about $61,700. The total 50-year present worth cost of these source control measures is $2,066,200, with an equivalent annual cost of $130,000. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $2,600 for hypolimnetic aeration to $8,623,000 for dredging. The total present worth costs of lake rehabilitation techniques would range from $3,900 for hypolimnetic aeration to $6,444,000 for dredging.

### Voltz Lake

Voltz Lake is a 52-acre lake located in the Town of Salem in Kenosha County. The lake drains to the Fox River via Trevor Creek. Certain geomorphological characteristics of Voltz Lake are set forth in Table C-124, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-42 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-42, all significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 34 privately owned onsite sewage disposal systems—33 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-125, all sources combined contribute about 170 pounds of phosphorus annually to Voltz Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also as indicated in Table C-125, under planned year 2000 land cover conditions, urban land uses in the watershed would increase by nearly four times, and sanitary sewer service would be provided. Increased urban land and construction activity runoff will result in the annual total phosphorus load increasing to about 265 pounds by 2000. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.04 milligram per liter (mg/l) and 0.06 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Voltz Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-126, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contribution include: the provision of sanitary sewer service, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the abovementioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-126 may include dredging, sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in

**Table C-124**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF VOLTZ LAKE**

| Characteristic | Description |
|---|---|
| Surface Area | 52 acres |
| Direct Tributary Drainage Area | 257 acres |
| Shoreline | 2.3 miles |
| Depth | |
| Maximum | 24 feet |
| Mean | 7 feet |
| Volume | 362 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 113 persons |
| General Existing Water Quality Conditions: | Excessive macrophyte growth; frequent fish winterkill; high nutrient concentrations; anaerobic conditions in hypolimnion during summer stratification |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.31 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

**Table C-125**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO VOLTZ LAKE: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 35 | 6 | 3.7 | 124 | 21 | 8.1 |
| Land under Development—Construction Activities (acres) | – | – | – | 4 | 198 | 74.7 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 33 | 96 | 57.2 | – | – | – |
| Rural Land Cover (acres) | 222 | 39 | 23.5 | 129 | 20 | 7.4 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 52 | 26 | 15.6 | 52 | 26 | 9.8 |
| Total | – | 167 | 100.0 | – | 265 | 100.0 |

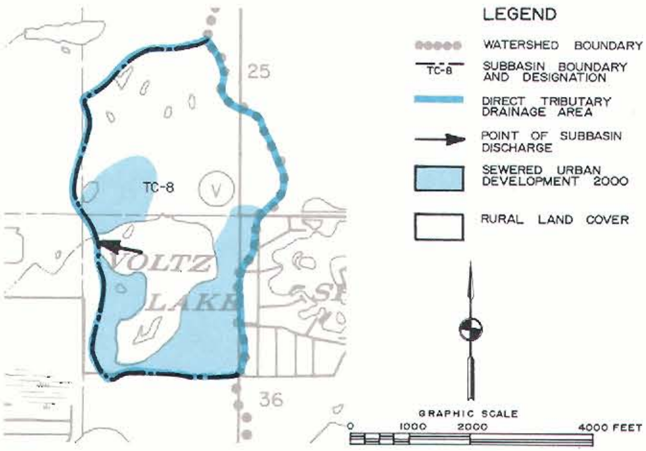
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-42

PLANNED LAND COVER DEVELOPMENT
IN THE DIRECT TRIBUTARY DRAINAGE
AREA OF VOLTZ LAKE: 2000




Voltz Lake has a direct tributary drainage area of about 257 acres. About 129 acres, or 50 percent of the drainage area, are planned to be in rural land cover, and 128 acres, or 50 percent, to be in urban land cover. Over the planning period an average of about four acres may be expected to be converted annually to urban land cover. It is estimated that a 70 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and construction erosion controls.

*Source: SEWRPC.*

a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Voltz Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control nutrient inputs to Voltz Lake would entail a total capital cost of about \$203,400, and an average annual operation and maintenance cost of about \$2,200. The total 50-year present worth cost of these nonpoint source control measures is \$186,000, with an equivalent annual cost of \$11,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from \$300 for nutrient inactivation to \$671,000 for dredging. The total present worth costs of the lake rehabilitation techniques would range from \$200 for nutrient inactivation to \$501,400 for dredging.

Lake Wandawega

Lake Wandawega is a 119-acre lake located in the Town of Sugar Creek in Walworth County. The lake is internally drained. Certain geomorphological characteristics of Lake Wandawega are set forth in Table C-127, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[11] Map C-43 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-43, none of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 164 privately owned onsite sewage disposal systems—77 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-128, all sources combined contribute about 400 pounds of phosphorus annually to Lake Wandawega during an average year of precipitation. The major source of phosphorus in the lake watershed is malfunctioning septic tank systems. These pollutant loads were estimated based on data developed during detailed field studies—conducted during a period of below average precipitation—interpreted against general pollutant source loading estimates for the lake watershed for average or typical year conditions. Also as indicated in Table C-128, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The observed total phosphorus concentration during study year 1976 spring overturn was 0.03 milligram per liter (mg/l), which is representative of a dry year condition. The water quality simulation analyses also indicated, during a year of average precipitation a spring concentration of phosphorus of 0.03 mg/l would be expected, and this same concentration is anticipated under year 2000 conditions. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Wandawega which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

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[11] *See separately published SEWRPC Community Assistance Planning Report on Water Quality Management for Wandawega Lake, Walworth County, for a more detailed discussion of the findings and recommendations of the detailed field study.*

Table C-126

WATER QUALITY MANAGEMENT MEASURES FOR VOLTZ LAKE IN KENOSHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis, Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | — | — | — | — | — | — | — | — | Protect public health and drinking water supplies; reduce nutrient concentrations | — |
| Minimum Rural Conservation Practices | $ <100 | $ 300 | $ <100 | $ 3,700 | $ 3,800 | $ <100 | 200 | $ 300 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 70 |
| Construction Erosion Control Practices[c] | 203,300 | 1,800 | 152,600 | 27,700 | 180,300 | 9,700 | 1,800 | 11,500 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 1,900 | 1,900 | Minimal | 100 | 100 | | |
| Total | 203,400 | 2,200 | 152,700 | 33,300 | 186,000 | 9,800 | 2,100 | 11,900 | | |
| Macrophyte Harvesting[d] | 23,300 | 3,300 | 17,400 | 52,000 | 69,400 | 1,100 | 3,300 | 4,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[e] | 600 | <100 | 400 | <100 | 500 | <100 | <100 | <100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 300 to 5,200 | — | 200 to 3,900 | — | 200 to 3,900 | <100 to 200 | — | <100 to 200 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,i] | 104,000 | — | 77,700 | — | 77,700 | 4,900 | — | 4,900 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[h,i] | 671,000 | — | 501,400 | — | 501,400 | 31,800 | — | 31,800 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Voltz Lake drainage basin include a capital cost over the period of 1975-2000 of $476,000, an average annual operation and maintenance cost of $3,600, and a total 50-year present worth cost of $323,000.*

[c] *Cost estimated to control erosion from the estimated 4.4 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *Cost estimated to harvest macrophytes from the 25 acres of Voltz Lake subject to excessive macrophyte growth.*

[e] *Cost estimated to aerate the entire hypolimnion of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 7.0 feet.*

[i] *The costs of sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-129, along with the associated costs and anticipated effectiveness. Measures to control septic tank contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices and low-cost measures to reduce pollutant runoff from urban lands.

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in the shallow waters of Lake Wandawega. When this problem is confirmed through further local study, the specific lake restoration or rehabilitation procedures which are appropriate should be identified for application, after implementation of the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-129 may include sediment covering, aeration, or dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may

## Table C-127

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE WANDAWEGA

| Characteristic | Description |
|---|---|
| Surface Area . . . . . . . . . . . . | 119 acres |
| Direct Tributary Drainage Area . . . . . . . . . . . . . . . . | 910 acres |
| Shoreline . . . . . . . . . . . . . . | 2.25 miles |
| Depth | |
| Maximum . . . . . . . . . . . | 8 feet |
| Mean . . . . . . . . . . . . . . . . | 4 feet |
| Volume . . . . . . . . . . . . . . . | 476 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] . . . . . | 530 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; frequent fish winterkill |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.23 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-128

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE WANDAWEGA: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) . . . . . . . . . . . . . | 282 | 58 | 14.0 | 282 | 58 | 14.0 |
| Land under Development—Construction Activities (acres) . . . . . . . . . . . . . . . . | — | — | — | — | — | — |
| Onsite Sewage Disposal Septic Tank Systems[b] . . . . . . . . . . . . . . . . . | 77 | 223 | 53.7 | 77 | 223 | 53.7 |
| Rural Land Cover (acres) . . . . . . . . . . . . | 628 | 74 | 17.8 | 628 | 74 | 17.8 |
| Livestock Operations (animal units) . . . . . . | — | — | — | — | — | — |
| Atmospheric Contribution (acres of receiving surface water) . . . . . . . . . . . . | 119 | 60 | 14.5 | 119 | 60 | 14.5 |
| Total | — | 415 | 100.0 | — | 415 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Table C-129

### WATER QUALITY MANAGEMENT MEASURES FOR LAKE WANDAWEGA IN WALWORTH COUNTY

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Septic Tank System Management[a] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ 100 | $ 1,100 | $ 100 | $ 13,400 | $ 13,500 | $ <100 | $ 900 | $ 1,000 | | |
| Low Cost Urban Land Management Practices | — | 500 | — | 6,900 | 6,900 | <100 | 400 | 500 | | 50 |
| Total | 100 | 1,600 | 100 | 20,300 | 20,400 | 200 | 1,300 | 1,500 | | |
| Macrophyte Harvesting[b] | 55,900 | 7,800 | 41,800 | 122,900 | 164,700 | 2,600 | 7,800 | 10,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[c] | 4,000 | 100 | 3,000 | 1,600 | 4,600 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[d,f] | 238,000 | — | 177,900 | — | 177,900 | 11,300 | — | 11,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[e,f] | 2,111,400 | — | 1,577,900 | — | 1,577,900 | 100,100 | — | 100,100 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Wandawega. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Wandawega drainage basin include a capital cost over the period of 1975-2000 of $346,500, an average annual operation and maintenance cost of $5,700, and a total 50-year present worth cost of $389,000.*

[b] *Cost estimated to harvest macrophytes from the 60 acres of Lake Wandawega subject to excessive macrophyte growth.*

[c] *Cost to aerate 20 acres of the lake.*

[d] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

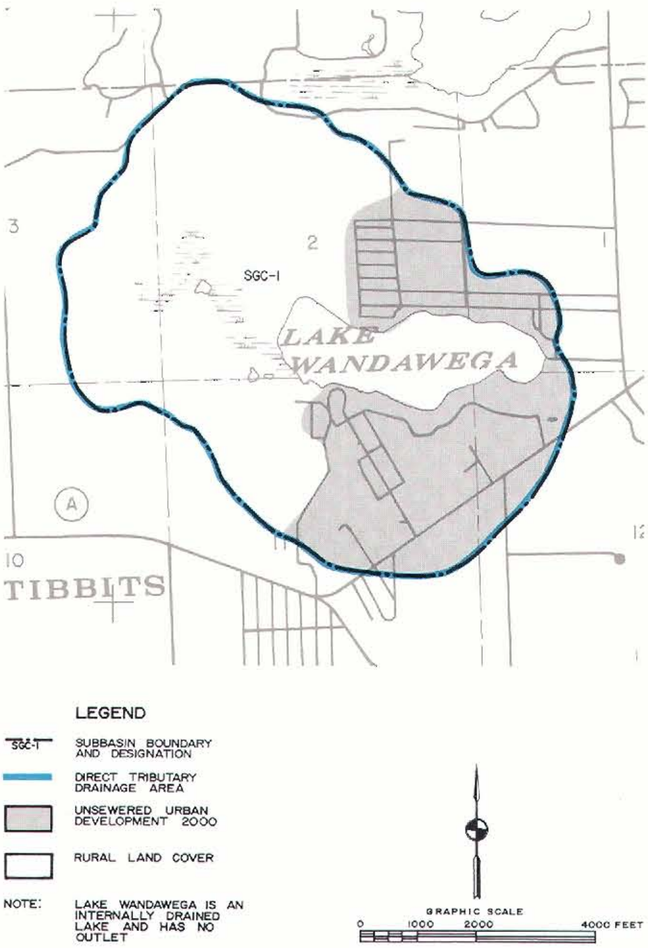
[e] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 4 feet. Actual costs may be higher depending upon lake physiography.*

[f] *The cost for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and* amount of material to be dredged or filled.

*Source: SEWRPC.*

Map C-43

PLANNED LAND COVER DEVELOPMENT
IN THE DIRECT TRIBUTARY DRAINAGE
AREA OF LAKE WANDAWEGA




Lake Wandawega has a direct tributary drainage area of about 910 acres. About 628 acres, or 69 percent of the drainage area, are planned to be in rural land cover, and 282 acres, or 31 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices— including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

be used to control the macrophyte growth which may interfere with the recreational use of the lake. Chemical treatment to control algae can be used if necessary, but only as a temporary solution to the problem. It should be emphasized, however, that the long-term maintenance of water quality in Lake Wandawega requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lake Wandawega would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $1,600. The total 50-year present worth cost of these nonpoint source control measures is $20,400, with an equivalent annual cost of $1,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,000 for aeration to $2,111,400 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,600 for aeration to $1,577,900 for dredging.

Waterford Impoundment—Buena Lake and Tichigan Lake

The Waterford Impoundment—Buena Lake and Tichigan Lake complex located on the Fox River is a 1,374 irregularly-shaped body of water located in the Town of Waterford, Racine County. For the areawide analysis of lake water quality management, this complex set of basins was evaluated as a single unit, including the section of the Fox River mainstream—upstream from the Tichigan Lake outlet—locally referred to as the "wide spread." Certain geomorphological characteristics of the Waterford Impoundment are set forth in Table C-130, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[12] Map C-44 presents a graphic summary of the proposed year 2000 land cover in the Buena-Tichigan Lake watershed. As shown on Map C-44, the portion of urban land within the Village of Waterford is to be served by sanitary sewers by the year 2000. As of 1975, an estimated 1,018 privately owned onsite sewage disposal systems—513 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-131, all sources combined contribute about 14,500 pounds of phosphorus annually to the Waterford Impoundment. The major direct tributary source of phosphorus in the lake watershed is livestock operations. However, the mainstream of the Fox River is also tributary to the Waterford Impoundment and over 84,000 pounds of phosphorus are annually contributed from tributary land uses in the upper portions of the Fox River watershed. Because of the large tributary drainage area and the relatively shallow depth coupled with large volumes of incoming water from the upstream tributary area, the Buena Lake portion of the Impoundment has a very short flushing time, and transports a major portion of these pollutants through the lake. This phenomenon

[12]*Report on Tichigan Lake, National Eutrophication Survey, U.S. Environmental Protection Agency, 1975.*

Table C-130

GEOMORPHOLOGICAL AND GENERAL WATER CHARACTERISTICS OF WATERFORD IMPOUNDMENT (BUENA-TICHIGAN LAKE COMPLEX)

| Characteristic | Description |
|---|---|
| Surface Area | 1,374 acres |
| Direct Tributary Drainage Area | 14,375 acres |
| Shoreline | 28 miles |
| Depth | |
| (Tichigan Lake) | |
| Maximum | 63 feet |
| (Buena Lake) | |
| Maximum | 8 feet |
| Mean | 6 feet |
| Volume | 8,244 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 4,289 persons |
| General Existing Water Quality Conditions: | Frequent blue-green algae blooms; frequent fish winterkill; high nutrient concentrations. Extreme turbidity which limits rooted aquatic plant growth and a desirable fishery. Because of the high flushing rate the water quality within Buena Lake is more characteristic of the Fox River main stream |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.60 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-131

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO THE WATERFORD IMPOUNDMENT: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,177 | 352 | 2.4 | 2,120 | 765 | 5.6 |
| Land under Development—Construction Activities (acres) | 36 | 1,620 | 11.2 | 36 | 1,620 | 12.0 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 513 | 1,485 | 10.2 | 82 | 237 | 1.7 |
| Rural Land Cover (acres) | 13,162 | 1,471 | 10.1 | 12,219 | 1,353 | 10.0 |
| Livestock Operations (animal units) | 1,347 | 8,890 | 61.4 | 1,347 | 8,890 | 65.6 |
| Atmospheric Contribution (acres of receiving surface water) | 1,374 | 687 | 4.7 | 1,374 | 687 | 5.1 |
| Total | – | 14,505[c] | 100.0 | – | 13,552[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

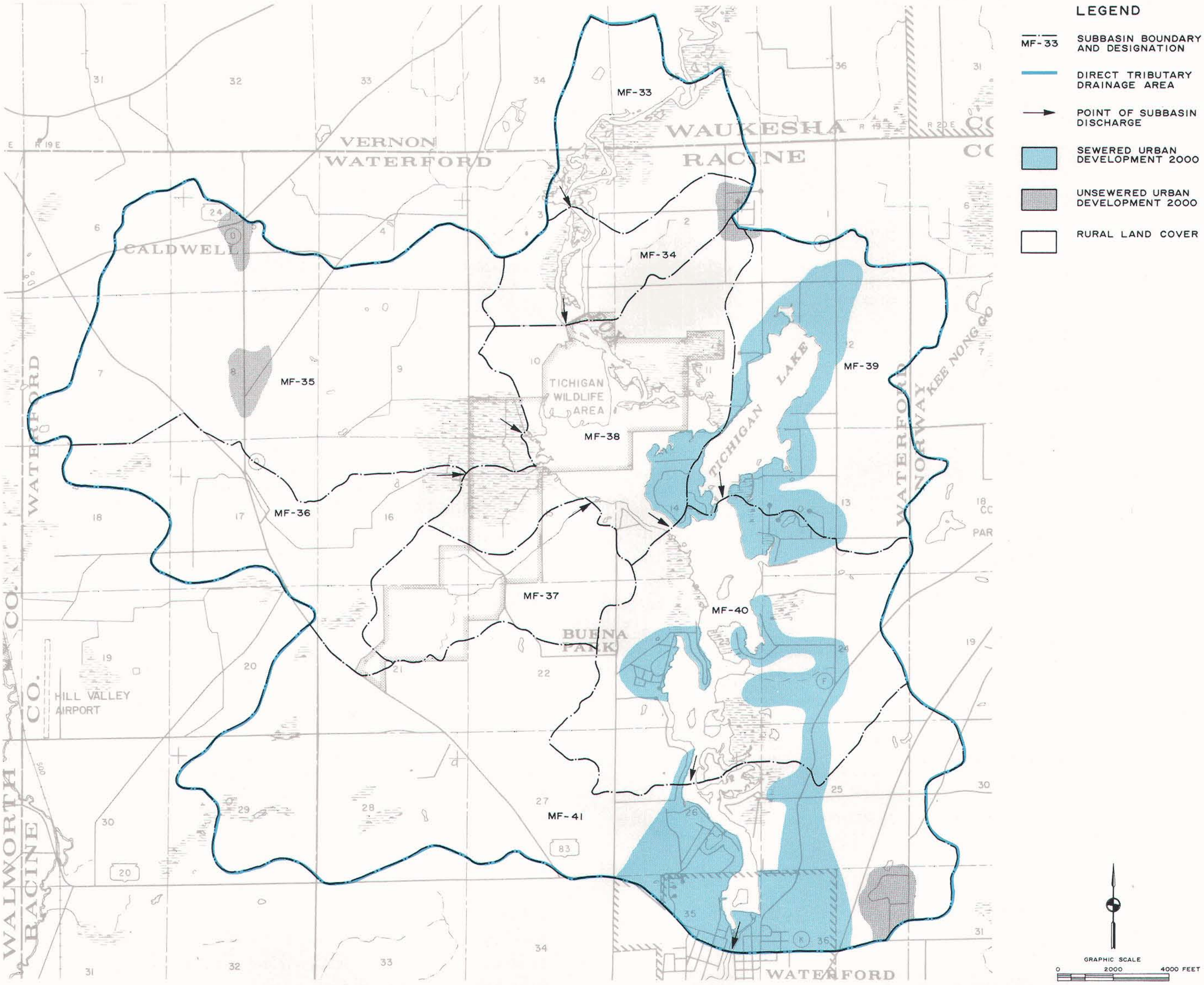
[c] *Does not include the 1975 estimated phosphorus load of 84,000 pounds per year, or the year 2000 anticipated phosphorus load of 49,000 pounds per year contributed by the large upstream portion of the upper Fox River watershed.*

*Source: SEWRPC.*

is not expected to occur within Tichigan Lake due to its depth and location, outside the hydraulic flowing channel of the Fox River mainstream. The following discussion, however, applies to the two lakes as a single system, since an assessment of the rates and extent of mixing between the two lake basins is a complex study requiring field work beyond the scope of this areawide water quality study. As further indicated in Table C-131 the extent of urban land uses in the watershed is expected to increase by about 73 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be reduced to about 13,500 pounds. The year 2000 conditions represent a 50 percent reduction in phosphorus loads to the Impoundment from the Upper Fox River watershed as a result of the extension of sanitary sewer service to most of the direct tributary area and diffuse source controls. The extension of sanitary sewer service to the direct tributary area will eliminate all but about 250 septic systems by the year 2000. Loadings from livestock operation are expected to continue to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The upstream phosphorus load to the impoundment under year 2000 conditions is estimated to be reduced to 49,000 pounds per year. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from stream inflow and direct drainage phosphorus loadings and lake and drainage basin characteristics, are 0.08 milligram per liter (mg/l) and 0.05 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in the Waterford Impoundment which appreciably exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. In recognizing the large drainage area, short flushing time, high phosphorus loading, and physical characteristics of the Buena Lake basin, Buena Lake cannot realistically be expected to achieve a water quality suitable for a productive warmwater fishery and recreational use classification. Therefore, it is recommended that the lake be classified as a limited recreation, warmwater fishery lake. Diffuse nonpoint source control measures should be implemented, however, to reduce the turbidity of Buena Lake in order to support a greater diversity and abundance of aquatic life—as required by desirable plant and fish species—and to improve the aesthetic condition of the Buena-Tichigan Impoundment. This should allow limited recreational use and warmwater fishery water use objectives to be met. However, given the current condition of Buena Lake and the expected limited effectiveness of existing nonpoint source controls in this instance, expensive nonpoint source control measures are probably not warranted. In comparison, Tichigan Lake—given its greater maximum depth of 63 feet, slower exchange (flushing) time, and other unique hydrologic characteristics—should be maintained in the warmwater fishery and full recreational

Map C-44

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF THE WATERFORD IMPOUNDMENT: 2000




The Waterford Impoundment has a direct tributary drainage area of about 14,375 acres. About 12,219 acres, or 85 percent of the drainage area, are planned to be in rural land cover, and 2,156 acres, or 15 percent, to be in urban land cover. Over the planning period an average of about 36 acres may be expected to be converted annually to urban land cover. A combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area to prevent further degradation of the Waterford Impoundment and to provide for full recreational use in the Tichigan Lake basin.

*Source: SEWRPC.*

water use classification. A thorough study is currently underway on Tichigan Lake to determine the hydraulic and hydrologic characteristics of the basin. This study should also assess the need for and feasibility of constructing a barrier of some form at the outlet to reduce the effect of the Fox River mainstream on the water quality of Tichigan Lake. Once a barrier is constructed—if one is found feasible—lake rehabilitation techniques could be undertaken, if needed.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-132, along with the associated costs and anticipated effectiveness. Measures to control livestock con-

## Table C-132

### WATER QUALITY MANAGEMENT MEASURES FOR THE WATERFORD IMPOUNDMENT (BUENA-TICHIGAN LAKES) IN RACINE COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 118,500 | $ 10,100 | $ 88,600 | $ 118,900 | $ 207,500 | $ 5,600 | $ 7,500 | $ 13,100 | | |
| Minimum Rural Conservation Practices | 2,600 | 22,200 | 1,900 | 270,900 | 272,800 | 100 | 17,200 | 17,300 | | |
| Construction Erosion Control Practices[d] | 2,079,000 | 18,000 | 1,560,400 | 283,700 | 1,844,100 | 99,000 | 1,800 | 100,800 | | |
| Low Cost Urban Land Management Practices | Minimal | 2,700 | Minimal | 40,400 | 40,400 | Minimal | 2,600 | 2,600 | | |
| Total | 2,200,100 | 53,000 | 1,650,900 | 713,900 | 2,364,800 | 104,700 | 29,100 | 133,800 | | 80 |
| Lake Drawdown (Buena Lake only) | Minimal | | — | Minimal | Minimal | — | Minimal | Minimal | Improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[e] (Tichigan Lake only) | 6,200 | 200 | 4,600 | 3,200 | 7,800 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] (Tichigan Lake only) | 3,100 to 39,100 | – | 2,300 to 29,200 | – | 2,300 to 29,200 | 100 to 1,900 | – | 100 to 1,900 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,h] (Tichigan Lake only) | 782,000 | – | 584,400 | – | 584,400 | 37,100 | – | 37,100 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Buena-Tichigan Lakes drainage basin include a capital cost over the period of 1975-2000 of $3,852,000, an average annual operation and maintenance cost of $33,700, and a total 50-year present worth cost of $2,688,800.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Buena-Tichigan Lakes. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Buena-Tichigan Lakes drainage basin include a capital cost over the period of 1975-2000 of $369,000, an average annual operation and maintenance cost of $8,300, and a total 50-year present worth cost of $487,400.*

[d] *Cost estimated to control erosion from the estimated 36 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to aerate the entire hypolimnion of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *Actual costs may vary depending on lake depth, sediment type, amount of material to be filled, and other factors.*

*Source: SEWRPC.*

tributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

The consideration of most lake restoration or rehabilitation procedures at this time should be with caution since problems would probably reoccur rapidly. However, lake drawdown, with subsequent fish restocking and bottom sediment removal or consolidation, would provide some measure of temporary water quality improvement. The implementation of hypolimnetic aeration, nutrient inactivation, and/or sediment covering for Tichigan Lake may be feasible as determined by the ongoing one-year lake study.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Buena-Tichigan Lakes would entail a total capital cost of about $2,200,100, and an average annual operation and maintenance cost of about $53,000. The total 50-year present worth cost of these source control measures is $2,364,800 with an equivalent annual cost of $133,800. If, in addition, rehabilitation techniques are found necessary, the capital cost of these would range from minimal for lake drawdown to $782,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from minimal cost for lake drawdown to $584,400 for sediment covering.

Waubeesee Lake
Waubeesee Lake is a 129-acre lake located in the Town of Norway in Racine County. The lake drains to the Wind Lake Drainage Canal. Certain geomorphological characteristics of Waubeesee Lake are set forth in Table C-133, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-45 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-45, a large portion of the urban land in the direct tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, estimated 243 privately owned onsite sewage disposal systems—219 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-134, all direct sources combined contribute about 1,400 pounds of phosphorus annually to Waubeesee Lake. The major direct tributary sources of phosphorus in the lake watershed are runoff from septic tank systems, although livestock operations, rural land runoff, and urban land runoff also contribute significant loads of phosphorus. In addition, 700 pounds of phosphorus are estimated to be contributed annually to Waubeesee Lake from drainage from Kee Nong Go Mong Lake. Also, as indicated in Table C-134, urban land uses in the watershed are expected to increase by about

Table C-133

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF WAUBEESEE LAKE

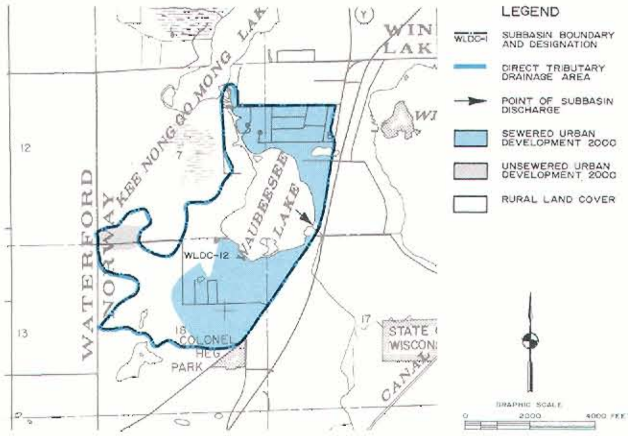
| Characteristic | Description |
|---|---|
| Surface Area | 129 acres |
| Direct Tributary Drainage Area | 553 acres |
| Shoreline | 3.1 miles |
| Depth | |
| Maximum | 73 feet |
| Mean | 19 feet |
| Volume | 2,450 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 302 persons |
| General Existing Water Quality Conditions: | Moderate macrophyte growth; occasional lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.60 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-45

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF WAUBEESEE LAKE: 2000




Waubeesee Lake has a direct tributary drainage area of about 553 acres. About 160 acres, or 29 percent of the drainage area, are planned to be in rural land cover, and 393 acres, or 71 percent, to be in urban land cover. Over the planning period an average of about eight acres may be expected to be converted annually to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and urban management practices—including low-cost urban practices, construction erosion controls, proper septic tank system management based on a site-by-site inspection and maintenance program, and additional urban practices.

*Source: SEWRPC.*

Table C-134

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO WAUBEESEE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 207 | 129 | 9.1 | 385 | 239 | 17.1 |
| Land under Development—Construction Activities (acres) | – | – | – | 8 | 353 | 25.2 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 219 | 634 | 44.7 | 103 | 298 | 21.3 |
| Rural Land Cover (acres) | 346 | 219 | 15.5 | 160 | 74 | 5.3 |
| Livestock Operations (animal units) | 56 | 370 | 26.1 | 56 | 370 | 26.4 |
| Atmospheric Contribution (acres of receiving surface water) | 129 | 65 | 4.6 | 129 | 65 | 4.7 |
| Total | – | 1,417[c] | 100.0 | – | 1,399[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 700 pounds per year, or the year 2000 anticipated phosphorus load of 200 pounds per year contributed by the drainage from the Lake Kee Nong Go Mong outlet.*

*Source: SEWRPC.*

85 percent under planned year 2000 land cover conditions although direct annual total phosphorus loadings are expected to remain about the same as under existing conditions. Livestock operations, septic tank systems, urban land stormwater runoff, and construction activities are expected to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions if drainage from nonpoint source controls are not implemented. The phosphorus load contributed from Kee Nong Go Mong Lake is expected to be reduced to about 200 pounds under year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from total phosphorus loadings and lake and drainage basin characteristics, are 0.12 milligram per liter (mg/l) and 0.09 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Waubeesee Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-135, along with the associated costs and anticipated

**Table C-135**

**WATER QUALITY MANAGEMENT MEASURES FOR WAUBEESEE LAKE IN RACINE COUNTY**

| | *Estimated Cost* 1980-2000 | | Economic Analysis | | | | | | | Cumulative *Reduction in* External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 4,900 | $ 400 | $ 3,700 | $ 4,900 | $ 8,600 | $ 200 | $ 300 | $ 500 | | |
| Rural Conservation Practices[d] | 2,500 | 900 | 1,900 | 1,000 | 2,900 | 100 | 100 | 200 | | |
| Construction Erosion Control Practices[e] | 369,600 | 3,200 | 277,400 | 50,400 | 327,800 | 17,600 | 3,200 | 20,800 | | |
| Low Cost Urban Land Management Practices | – | 500 | – | 7,200 | 7,200 | – | 500 | 500 | | |
| Additional Urban Land Management Practices[f] | 10,200 | 5,200 | 7,800 | 61,500 | 69,300 | 500 | 3,900 | 4,400 | | 85 |
| Total | 387,200 | 10,200 | 290,800 | 125,000 | 415,800 | 18,400 | 8,000 | 26,400 | | |
| Macrophyte Harvesting[g] | 18,600 | 2,600 | 13,900 | 41,000 | 54,900 | 900 | 2,600 | 3,500 | Control excessive macrophyte growth, aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[h] | 9,400 | 200 | 7,000 | 3,200 | 10,200 | 400 | 700 | 1,100 | Prevent anaerobic conditions (*lack of oxygen*) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[i] | 4,700 to 12,900 | – | 3,500 to 9,600 | – | 3,500 to 9,600 | 200 to 600 | – | 200 to 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[j,k] | 258,000 | – | 192,800 | – | 192,800 | 12,200 | – | 12,200 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Waubeesee Lake drainage basin include a capital cost over the period of 1975-2000 of $132,000, an average annual operation and maintenance cost of $1,000, and a total 50-year present worth cost of $89,600.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Waubeesee Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Waubeesee Lake drainage basin include a capital cost over the period of 1975-2000 of $463,500, an average annual operation and maintenance cost of $4,100, and a total 50-year present worth cost of $434,300.*

[d] *Rural land management practices necessary to achieve a 50 percent reduction in rural diffuse source pollutant loads.*

[e] *Cost estimated to control erosion from the estimated 8 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[f] *Urban land management practices necessary to achieve a 50 percent reduction in urban diffuse source pollutant loads.*

[g] *Cost estimated to harvest macrophytes from the 20 acres of Waubeesee Lake subject to excessive macrophyte growth.*

[h] *Cost estimated to aerate the entire hypolimnion of the lake.*

[i] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[j] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[k] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, measures to reduce pollutant runoff from rural lands by 50 percent, low-cost measures to reduce pollutant runoff from urban lands, measures to reduce pollutant runoff from urban lands by 50 percent, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-135 may include sediment covering and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Hypolimnetic aeration may also be a feasible method to eliminate anoxic conditions in the hypolimnion during summer stratification. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Waubeesee Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Waubeesee Lake would entail a total capital cost of about $387,200, and an average annual operation and maintenance cost of about $10,200. The total 50-year present worth cost of these diffuse source control measures, useful in comparing the long-term costs of alternative control measures, is $415,800, with an equivalent annual cost of $26,400. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,700 for nutrient inactivation to $258,000 for sediment covering. The total present worth costs of lake rehabilitation techniques would range from $3,500 for nutrient inactivation to $192,800 for sediment covering.

Wind Lake

Wind Lake is a 936-acre lake located in the Town of Norway in Racine County. The lake drains to the Wind Lake Drainage Canal. Certain geomorphological characteristics of Wind Lake are set forth in Table C-136, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-46 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-46 a large portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 681 privately owned onsite sewage disposal systems—609 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-137, all tributary sources combined contribute about 20,900 pounds of phosphorus annually to Wind Lake. The existing major direct tributary phosphorus loadings to the lake are estimated to originate from rural land runoff and runoff from live-

Table C-136

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF WIND LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 936 acres |
| Direct Tributary Drainage Area | 8,381 acres |
| Shoreline | 9.3 miles |
| Depth | |
| Maximum | 47 feet |
| Mean | 9.6 feet |
| Volume | 8,995 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 2,452 persons |
| General Existing Water Quality Conditions: | Blue-green algae blooms; excessive macrophyte growth; moderate to high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.60 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-137

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO WIND LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 637 | 162 | 0.8 | 1,479 | 376 | 2.0 |
| Land under Development—Construction Activities (acres) | – | – | – | 71 | 3,195 | 17.0 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 609 | 1,763 | 8.4 | 56 | 162 | 0.8 |
| Rural Land Cover (acres) | 7,744 | 12,813 | 61.4 | 6,831 | 8,951 | 47.5 |
| Livestock Operations (animal units) | 862 | 5,689 | 27.2 | 862 | 5,689 | 30.2 |
| Atmospheric Contribution (acres of receiving surface water) | 936 | 468 | 2.2 | 936 | 468 | 2.5 |
| Total | – | 20,895[c] | 100.0 | – | 18,841[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

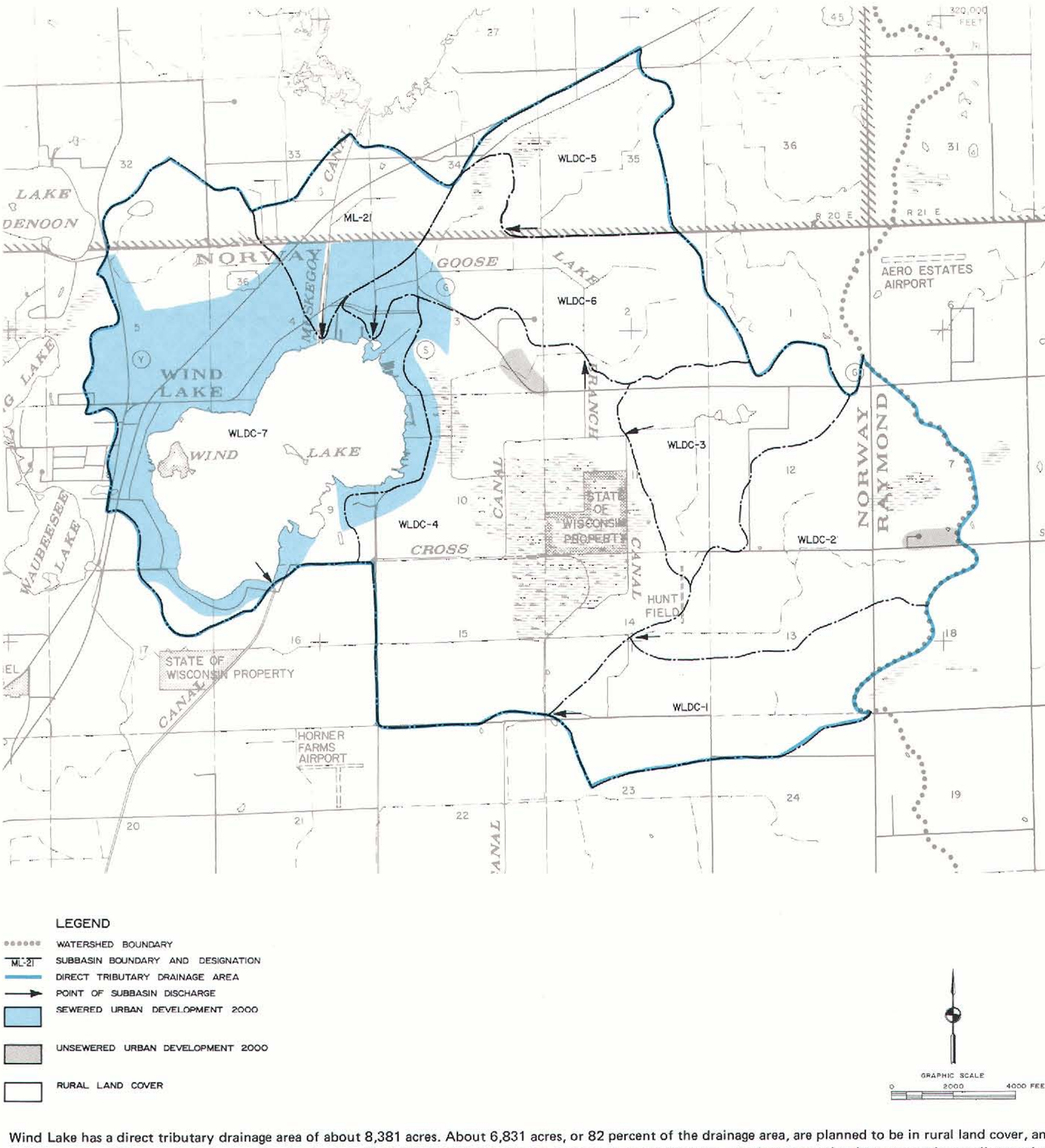
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 4,380 pounds per year, nor the year 2000 anticipated phosphorus load of 400 pounds per year contributed from the Big Muskego Lake.*

*Source: SEWRPC.*

Map C-46

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF WIND LAKE: 2000




Wind Lake has a direct tributary drainage area of about 8,381 acres. About 6,831 acres, or 82 percent of the drainage area, are planned to be in rural land cover, and 1,550 acres, or 18 percent, to be in urban land cover. Over the planning period an average of about 71 acres may be expected to be converted annually to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and urban management practices—including low-cost urban practices, construction erosion controls, proper septic tank system management based on a site-by-site inspection and maintenance program, and additional urban practices.

*Source: SEWRPC.*

loadings expected to decrease to about 18,800 pounds as a result of the reduced rural land pollutant runoff loadings and the elimination of most malfunctioning septic tank systems through the provision of sanitary sewer service. Unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from rural land runoff and livestock operations may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. In addition, the phosphorus load contributed to Wind Lake from drainage from Big Muskego Lake is expected to be reduced to 400 pounds per year under year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.17 milligram per liter (mg/l) and 0.13 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Wind Lake which exceed the phosphorus level estimated to be necessary to maintain water quality suitable for recreational use and for the maintenance of a warmwater fishery.

### Table C-138

### WATER QUALITY MANAGEMENT MEASURES FOR WIND LAKE IN RACINE COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[a,b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 85 |
| Livestock Waste Control | $ 75,900 | $ 6,500 | $ 56,700 | $ 76,100 | $ 132,800 | $ 3,600 | $ 4,800 | $ 8,400 | | |
| Rural Conservation Practices[d] | 988,700 | 128,700 | 832,600 | 648,100 | 1,480,700 | 52,800 | 41,100 | 93,900 | | |
| Construction Erosion Control Practices[e] | 3,280,200 | 28,400 | 2,462,000 | 447,700 | 2,909,700 | 156,200 | 28,400 | 184,600 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,700 | Minimal | 25,800 | 25,800 | Minimal | 1,600 | 1,600 | | |
| Additional Urban Land Management Practices | 44,500 | 22,800 | 31,600 | 267,700 | 299,300 | 2,000 | 17,000 | 19,000 | | |
| Total | 4,389,300 | 188,100 | 3,382,900 | 1,465,400 | 4,848,300 | 214,600 | 92,900 | 307,500 | | |
| Macrophyte Harvesting[f] | 279,600 | 39,000 | 209,000 | 457,300 | 668,300 | 13,300 | 29,100 | 42,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Nutrient Inactivational[g] | 14,000 to 93,600 | – | 10,500 to 69,900 | – | 10,500 to 69,900 | 700 to 4,400 | – | 700 to 4,400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,j] | 1,872,400 | – | 1,399,200 | – | 1,399,200 | 88,800 | – | 88,800 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[i,j] | 8,156,100 | – | 6,095,000 | – | 6,095,000 | 386,700 | – | 386,700 | Deepen lake; reduce macrophyte growth | No additional reduction |

*[a] The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Fox River subregional area.*

*[b] Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Fox River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Wind Lake drainage basin include a capital cost over the period of 1975-2000 of $5,960,000, an average annual operation and maintenance cost of $44,700, and a total 50-year present worth cost of $4,043,900.*

*[c] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Wind Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Wind Lake drainage basin include a capital cost over the period of 1975-2000 of $252,000, an average annual operation and maintenance cost of $23,700, and a total 50-year present worth cost of $261,800.*

*[d] Cost estimated to reduce rural diffuse source pollutant loads by 75 percent.*

*[e] Cost estimated to control erosion from the estimated 71 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*[f] Cost estimated to harvest macrophytes from the 300 acres of Wind Lake subject to excessive macrophyte growth.*

*[g] The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

*[h] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[i] Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 9.6 feet.*

*[j] The cost for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-138, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum and additional measures to reduce pollutant runoff from rural lands by 75 percent measures to reduce pollutant runoff from urban lands by 50 percent, and construction erosion control practices.

If nutrient loadings are reduced, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. This is especially true of a large, relatively shallow lake, such as Wind Lake. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Appropriate restoration measures may include limited dredging, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Wind Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source measures to control nutrient inputs to Wind Lake would entail a total capital cost of about $4,389,000 and an average annual operation and maintenance cost of about $188,100. The total 50-year present worth cost of these control measures, useful in comparing the long-term costs of alternative control measures, is $4,848,000, with an equivalent annual cost of $307,500. The estimated capital cost of inland lake rehabilitation measures could be expected to range from $14,000 for nutrient inactivation to $8,156,100 for dredging.

## MILWAUKEE RIVER WATERSHED LAKES

### Barton Pond

Barton Pond is a 67-acre lake located in the City of West Bend in Washington County. The pond is an impoundment of the mainstem of the Milwaukee River at West Bend. Certain geomorphological characteristics of Barton Pond are set forth in Table C-139, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-47 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-47 a portion of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 13 privately owned onsite sewage disposal systems—one located in an area covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-140, all sources combined contribute about 900 pounds of phosphorus annually to Barton Pond. The major source of phosphorus in the lake watershed is construction runoff. Additionally about 11,400 pounds of phosphorus are contributed annually from the large upstream tributary area via the Milwaukee River. As indicated in Table C-140, the extent of urban land uses in the watershed is expected to increase by about 250 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the

*Table C-139*

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BARTON POND

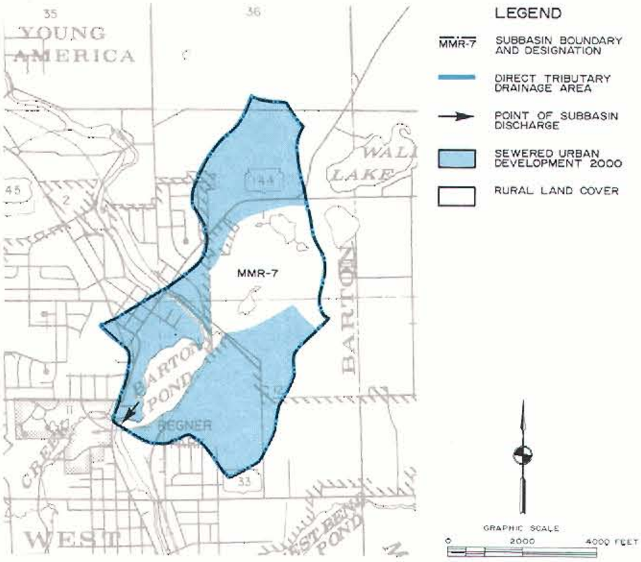
| Characteristic | Description |
|---|---|
| Surface Area | 67 acres |
| Direct Tributary Drainage Area | 687 acres |
| Shoreline | 3.0 miles |
| Depth | |
| Maximum | 5 feet |
| Mean | 3 feet |
| Volume | 189 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 655 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; potential for fishkills as a result of oxygen deficits during the summer months; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.3 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-47

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF BARTON POND: 2000




Barton Pond has a direct tributary drainage area of about 687 acres. About 172 acres, or 25 percent of the drainage area, are planned to be in rural land cover, and 515 acres, or 75 percent, to be in urban land cover. Over the planning period an average of about 17 acres may be expected to be converted annually to urban land cover. It is estimated that no reduction in direct tributary nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the pond. However, to provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and construction erosion controls should be implemented.

*Source: SEWRPC.*

Table C-140

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BARTON POND: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 136 | 77 | 8.3 | 498 | 150 | 15.5 |
| Land under Development—Construction Activities (acres) | 17 | 758 | 81.3 | 17 | 758 | 78.6 |
| Onsite Sewage Disposal Septic Tank Systems[b] | < 5 | 3 | 0.3 | < 5 | 3 | 0.3 |
| Rural Land Cover (acres) | 534 | 61 | 6.5 | 172 | 20 | 2.1 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 67 | 34 | 3.6 | 67 | 34 | 3.5 |
| Total | – | 933[c] | 100.0 | – | 965[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 11,360 pounds per year, or the year 2000 anticipated phosphorus load of 4,330 pounds per year, contributed by the upstream tributary area of the Upper Milwaukee River watershed.*

*Source: SEWRPC.*

lake expected to increase slightly to about 965 pounds as a result of increased urban development. Loadings from the construction activities are expected to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. In addition, approximately 4,300 pounds of phosphorus will be contributed annually following a 25 percent reduction of total phosphorus loadings by the implementation of various nonpoint source control measures and substantial point source reductions in the upstream watershed area. The estimated total phorphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.05 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Barton Pond which exceed, and meet, respectively, the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-141, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-141 may include lake aeration, dredging, and sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Barton Pond requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient input to Barton Pond would entail a total capital cost of about

**Table C-141**

**WATER QUALITY MANAGEMENT MEASURES FOR BARTON POND IN WASHINGTON COUNTY**

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Minimum Rural Conservation Practices | $ 100 | $ 600 | $ 100 | $ 7,500 | $ 7,600 | $ <100 | $ 500 | $ 600 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Construction Erosion Control Practices[c] | 785,400 | 6,800 | 589,500 | 107,200 | 696,700 | 37,400 | 6,800 | 44,200 | | |
| Low Cost Urban Land Management Practices | Minimal | 500 | Minimal | 8,000 | 8,000 | Minimal | 500 | 500 | | |
| Total | 785,500 | 7,900 | 589,600 | 122,700 | 712,300 | 37,500 | 7,800 | 45,300 | | 75 |
| Aeration[d] | 6,000 | 200 | 4,500 | 2,400 | 6,900 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[e,f] | 134,000 | – | 100,100 | – | 100,100 | 6,400 | – | 6,900 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 1,296,900 | – | 969,200 | – | 969,200 | 61,500 | – | 64,500 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Upper Milwaukee River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Upper Milwaukee River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Barton Pond drainage basin include a capital cost over the period of 1975-2000 of $48,000, an average annual operation and maintenance cost of $16,170, and a total 50-year present worth cost of $115,800.*

[c] *Cost estimated to control erosion from the estimated 17 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *Cost estimated to aerate 30 acres of the lake.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The cost of sediment covering and dredging projects will vary widely depending upon such factors as lake depth, size, type of material to be dredged or filled.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 3 feet.*

*Source: SEWRPC.*

$785,500, and an average annual operation and maintenance cost of about $7,900. The total 50-year present worth cost of these nonpoint source control measures is $712,300, with an equivalent annual cost of $45,300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $6,000 for lake aeration to $1,296,900 for dredging. The total present worth of these lake rehabilitation techniques would range from $500 for aeration to $969,200 for dredging.

Cedar Lake

Cedar Lake is a 932-acre lake located in the Towns of Polk and West Bend in Washington County. The lake drains to the Milwaukee River via Cedar Creek and Little Cedar Lake. Certain geomorphological characteristics of Cedar Lake are set forth in Table C-142, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-48 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-48, none of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 593 privately owned onsite sewage disposal systems—336 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.[13]

[13]*The provision of sanitary sewer service to the lake watershed was proposed in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin. However, field studies conducted by the Wisconsin Department of Natural Resources indicated that sanitary sewer service is probably not required if proper septic tank system mainteance were assured. As presented in the point source element discussion in Chapter 4 of this Volume, sanitary sewer service is no longer recommended for the Cedar Lake watershed.*

Table C-142

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF CEDAR LAKE

| Characteristic | Description |
|---|---|
| Surface Area ........... | 932 acres |
| Direct Tributary Drainage Area ............... | 5,495 acres |
| Shoreline ............ | 3.8 miles |
| Depth | |
| Maximum .......... | 105 feet |
| Mean .............. | 34 feet |
| Volume .............. | 31,983 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] .... | 2,022 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; moderate macrophyte growth; low to moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.41 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-143

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO CEDAR LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) ............. | 822 | 40 | 2.7 | 822 | 40 | 2.7 |
| Land under Development—Construction Activities (acres) .................. | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] .................. | 336 | 486 | 33.3 | 336 | 486 | 33.3 |
| Rural Land Cover (acres) ............. | 4,673 | 98 | 6.7 | 4,673 | 98 | 6.7 |
| Livestock Operations (animal units) ...... | 562 | 371 | 25.4 | 562 | 371 | 25.4 |
| Atmospheric Contribution (acres of receiving surface water) ............. | 932 | 466 | 31.9 | 932 | 466 | 31.9 |
| Total | – | 1,461[c] | 100.0 | – | 1,461[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

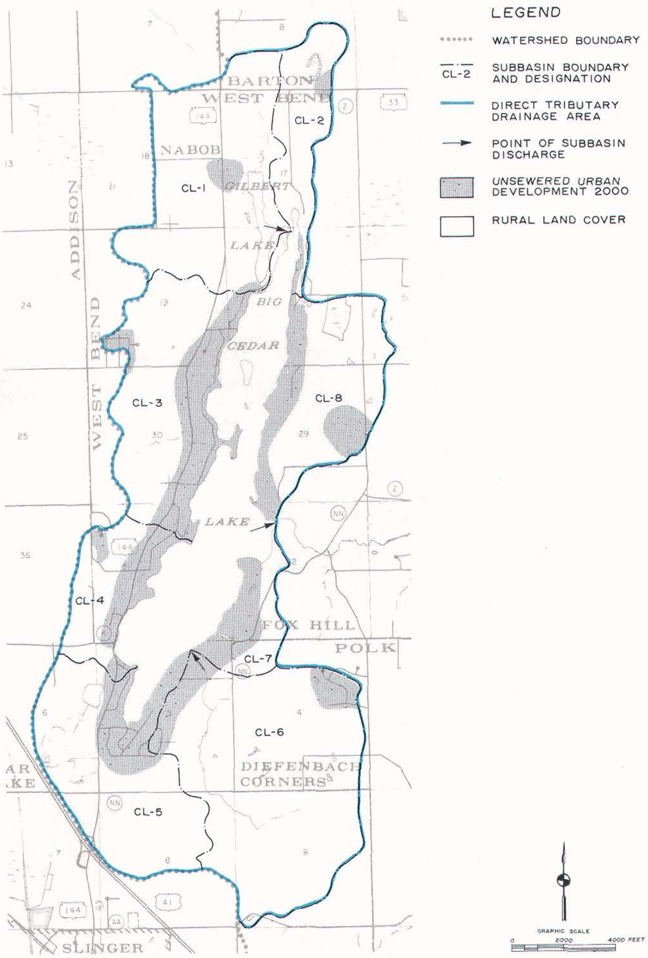
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Includes phosphorus loads from groundwater. The lake study conducted by the Wisconsin Department of Natural Resources reported that groundwater phosphorus loads, which may be contributed from natural sources, land surface seepage, and outlying septic systems, are higher than the observed direct septic system phosphorus loads to the lake.*

*Source: SEWRPC.*

Map C-48

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF CEDAR LAKE: 2000




Cedar Lake has a direct tributary drainage area of about 5,495 acres. About 4,673 acres, or 85 percent of the drainage area, are planned to be in rural land cover, and 822 acres, or 15 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

As indicated in Table C-143, based on Wisconsin Department of Natural Resources field study results, water quality simulation analyses, and phosphorus loading estimates, all direct tributary sources combined contribute about 1,500 pounds of phosphorus annually to Cedar Lake. The major source of phosphorus to the lake is septic tank systems. Urban land uses in the lake watershed are not expected to increase under planned year 2000 land cover conditions, and annual total phosphorus loadings to the lake are expected to remain constant if pollutant controls are not implemented. While no significant construction activities should occur within the lake watershed through the year 2000, it must be recognized that if such activities do occur, the potential for excessive pollutant contributions to the lake from these activities exists and effective control measures should accordingly be implemented to avoid these excessive contributions. The estimated total phosphorus concentration during spring overturn under both existing and anticipated year 2000 conditions, as estimated from Wisconsin Department of Natural Resources field study results, and water quality model simulation analyses and phosphorus loading estimates, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Cedar Lake which meet the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-144, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other recommended measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. As this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-144 may include nutrient inactivation. The feasibility of this measure would have to be assessed in a preliminary engineering study. Additional management measures, such as weed havesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Cedar Lake requires that the recommended level of nutrient input reductions be achieved.

**Table C-144**

**WATER QUALITY MANAGEMENT MEASURES FOR CEDAR LAKE IN WASHINGTON COUNTY**

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis — Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | | | | | | | | | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 40 |
| Livestock Waste Control[b] | $ 49,500 | $ 4,200 | $ 37,000 | $ 49,600 | $ 86,600 | $ 2,300 | $ 3,100 | $ 5,400 | | |
| Minimum Rural Conservation Practices and Streambank Protection | 1,000 | 8,200 | 700 | 99,800 | 100,500 | <100 | 6,300 | 6,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,400 | Minimal | 20,100 | 20,100 | Minimal | 1,300 | 1,300 | | |
| Total | 50,500 | 13,800 | 37,700 | 169,500 | 207,200 | 2,400 | 10,700 | 13,100 | | |
| Macrophyte Harvesting[c] | 93,200 | 13,000 | 69,600 | 204,900 | 274,500 | 4,400 | 13,000 | 17,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Nutrient Inactivation[d] | 43,800 to 93,200 | – | 32,700 to 69,600 | – | 32,700 to 69,600 | 2,100 to 4,400 | – | 2,100 to 4,400 | Accelerate lake improvement; prevent release of nutrient from sediment; remove nutrients from water body | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Cedar Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Cedar Lake drainage basin include a capital cost over the period of 1975-2000 of $229,500, an average annual operation and maintenance cost of $5,400, and a total 50-year present worth cost of $312,900.*

[b] *If adequate livestock waste control is determined following a field inspection by soil conservation specialists, the above-cited control costs may be substantially revised.*

[c] *Cost estimated to harvest macrophytes from the 100 acres of Cedar Lake subject to excessive macrophyte growth.*

[d] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

*Source: SEWRPC.*

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Cedar Lake would entail a total capital cost of about $50,500, and an average operation and maintenance cost of about $13,800. The total 50-year present worth cost of these nonpoint source control measures is $207,200, with an equivalent annual cost of $13,100. If, in addition, rehabilitation techniques are found necessary, the cost of nutrient inactivation would range from $43,800 to $93,200. The total present worth of nutrient inactivation would range from $32,700 to $69,600 for nutrient inactivation.

Green Lake

Green Lake is a 71-acre lake located in the Town of Farmington in Washington County. Green Lake is drained by an unnamed tributary to the North Branch of the Milwaukee River. Certain geomorphological characteristics of Green Lake are set forth in Table C-145, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-49 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-49 none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by year 2000. As of 1975, an estimated 60 privately owned onsite sewage disposal systems—39 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.
the lake watershed area.

Table C-145

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF GREEN LAKE

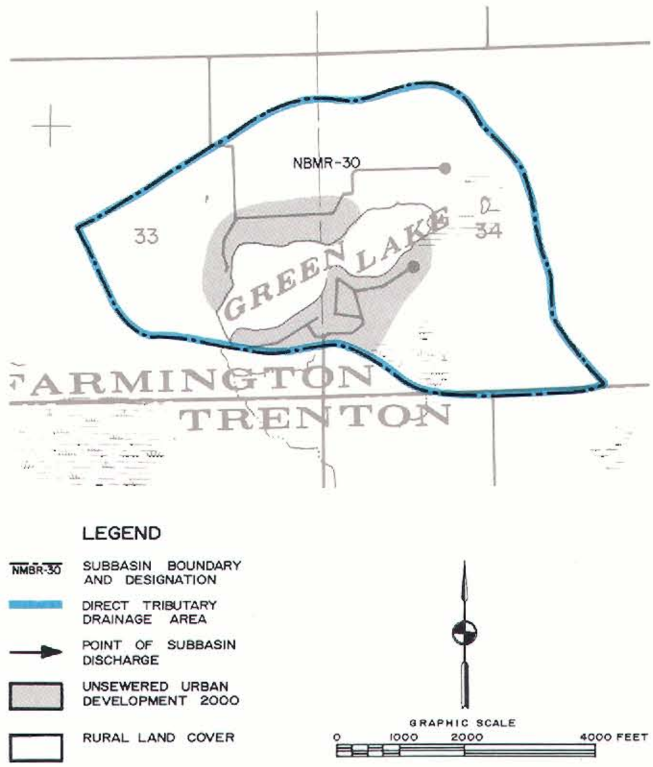
| Characteristic | Description |
|---|---|
| Surface Area | 71 acres |
| Direct Tributary Drainage Area | 505 acres |
| Shoreline | 1.8 miles |
| Depth | |
| Maximum | 37 feet |
| Mean | 17 feet |
| Volume | 1,195 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 218 persons |
| General Existing Water Quality Conditions: | Moderate nutrient concentrations; frequent dissolved oxygen depletion in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.63 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-49

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF GREEN LAKE: 2000




Green Lake has a direct tributary drainage area of about 505 acres. About 358 acres, or 71 percent of the drainage area, are planned to be in rural land cover, and 147 acres, or 29 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-146

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO GREEN LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 147 | 19 | 9.3 | 147 | 19 | 9.3 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 39 | 113 | 55.1 | 39 | 113 | 55.1 |
| Rural Land Cover (acres) | 358 | 37 | 18.0 | 358 | 37 | 18.0 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 71 | 36 | 17.6 | 71 | 36 | 17.6 |
| Total | – | 205 | 100.0 | – | 205 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

As indicated in Table C-146, all sources combined contribute about 200 pounds of phosphorus annually to Green Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also as indicated in Table C-146, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from septic tank systems may be expected to continue to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.03 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Green Lake which exceed the recommended level for recreational use and for maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-147, along with the associated costs and anticipated effectiveness. Needed measures to control phosphorus contributions include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-147 may include hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Green Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Green Lake would entail a total capital cost of about

Table C-147

WATER QUALITY MANAGEMENT MEASURES FOR GREEN LAKE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis – Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ <100 | $ 600 | $ 100 | $ 6,800 | $ 6,900 | $ <100 | $ 400 | $ 500 | | |
| Low Cost Urban Land Management Practices | Minimal | 200 | Minimal | 3,600 | 3,600 | Minimal | 200 | 200 | | |
| Total | 100 | 800 | 100 | 10,400 | 10,500 | 100 | 600 | 700 | | 60 |
| Hypolimnetic Aeration[b] | 5,400 | 100 | 4,000 | 1,600 | 5,600 | 300 | 100 | 400 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[c] | 2,700 to 7,100 | – | 2,000 to 5,300 | – | 2,000 to 5,300 | 100 to 300 | – | 100 to 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[d,e] | 142,000 | – | 106,100 | – | 106,100 | 6,700 | – | 6,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

*[a] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Green Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Green Lake drainage basin include a capital cost over the period of 1975-2000 of $175,500, an average annual operation and maintenance cost of $2,200, and a total 50-year present worth cost of $174,000.*

*[b] Cost estimated to aerate the entire hypolimnion of the lake.*

*[c] The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

*[d] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[e] Cost of sediment covering will vary widely depending on such factors as lake depth, lake size, and amount of fill required.*

*Source: SEWRPC.*

$100, with an average annual operation and maintenance cost of about $800. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $10,500, with an equivalent annual cost of $700. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $2,700 for nutrient inactivation to $142,000 for sediment covering. The total present worth of these rehabilitation measures would range from $2,000 for nutrient inactivation to $106,100 for sediment covering.

Little Cedar Lake

Little Cedar Lake is a 246-acre lake located in the Town of West Bend in Washington County. The lake drains to the main branch of the Milwaukee River via Cedar Creek. Certain geomorphological characteristics of Little Cedar Lake are set forth in Table C-148, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-50 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-50, none of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 164 privately owned onsite sewage disposal systems—54 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.[14]

As indicated in Table C-149, based on Wisconsin Department of Natural Resources field study results, water quality simulation analyses, and phosphorus loading estimates, all direct tributary sources combined contribute about 450 pounds of phosphorus annually to Little Cedar Lake. The major source of phosphorus in the lake watershed is septic systems. In addition, approximately 440 pounds of phosphorus are contributed annually from the drainage from Cedar Lake. Urban land uses in the lake watershed are not expected to increase under planned year 2000 land cover conditions, and annual total phosphorus loadings to the lake are expected to remain at about 450 pounds from the direct tributary area. While no significant construction activities are planned to occur within the watershed through the year 2000, it must be recognized that if such activities

[14]*The provision of sanitary sewer service to the lake watershed was proposed in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin. However, field studies conducted by the Wisconsin Department of Natural Resources have demonstrated that sanitary sewer service is probably not required if proper septic tank system maintenance is assured. As presented in the point source element discussion in Chapter 4 of this Volume sanitary sewer service is no longer recommended for the Little Cedar Lake watershed.*

Table C-148

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LITTLE CEDAR LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 246 acres |
| Direct Tributary Drainage Area | 1,718 acres |
| Shoreline | 4.35 miles |
| Depth | |
| Maximum | 56 feet |
| Mean | 13 feet |
| Volume | 3,153 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 567 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; slight macrophyte growth; portions of hypolimnion void of oxygen during summer months; moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.46 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-149

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LITTLE CEDAR LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 313 | 26 | 5.7 | 313 | 26 | 5.7 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 54 | 156 | 34.4 | 54 | 156 | 34.4 |
| Rural Land Cover (acres) | 1,405 | 78 | 17.2 | 1,405 | 78 | 17.2 |
| Livestock Operations (animal units) | 106 | 70 | 15.5 | 106 | 70 | 15.5 |
| Atmospheric Contribution (acres of receiving surface water) | 246 | 123 | 27.2 | 246 | 123 | 27.2 |
| Total | – | 453[c] | 100.0 | – | 453[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

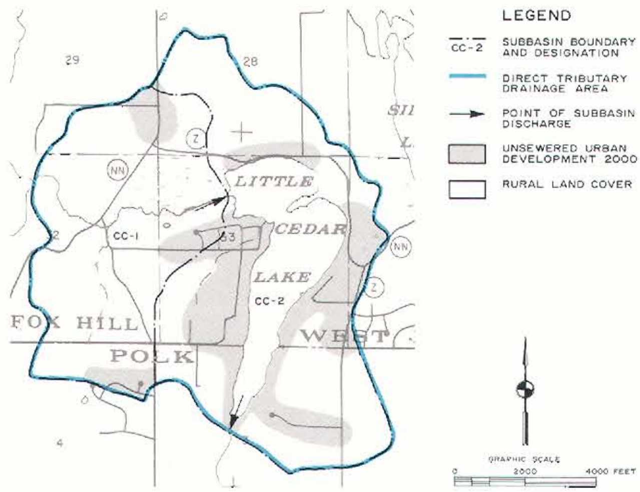
[b] *Includes phosphorus loads from groundwater. The lake study conducted by the Wisconsin Department of Natural Resources reported that groundwater phosphorus loads, which may be contributed from natural sources, land surface seepage, and outlying septic systems, are higher than direct septic system phosphorus loads to the lake.*

[c] *Does not include the 1975 estimated phosphorus load of 440 pounds per year, or the year 2000 anticipated phosphorus load of 230 pounds per year, contributed by the outflow from Big Cedar Lake.*

*Source: SEWRPC.*

Map C-50

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LITTLE CEDAR LAKE: 2000




Little Cedar Lake has a direct tributary drainage area of about 1,718 acres. About 1,405 acres, or 82 percent of the drainage area, are planned to be in rural land cover, and 313 acres, or 18 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

occur, the potential for excessive pollutant contributions to the lake from these activities would exist and effective control measures should accordingly be implemented. The estimated total phosphorus concentration during spring overturn under both existing and anticipated year 2000 conditions, as estimated from water quality model simulation analyses, Wisconsin Department of Natural Resources field study results, and phosphorus loading estimates, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Little Cedar Lake which meet the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-150, along with the associated costs and anticipated effectiveness. Recommended measures include: improved septic tank system management, livestock waste control, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-150, may include dredging, sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Little Cedar Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Little Cedar Lake would entail a total capital cost of about $9,600, and an average annual operation and maintenance cost of about $3,800. The total 50-year present worth cost of these source control measures is $54,200, with an equivalent annual cost of $3,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $9,100 for nutrient inactivation to $793,600 for dredging. The total present worth of these rehabilitation measures would range from $6,800 for nutrient inactivation to $593,100 for dredging.

## Lucas Lake

Lucas Lake is a 78-acre lake located in the Town of West Bend in Washington County. The lake drains into the Milwaukee River via Silver Creek. Certain geomorphological characteristics of Lucas Lake are set forth in Table C-151, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-51 presents a graphic summary of the proposed year 2000 land cover in the direct tributary lake watershed. As shown on Map C-51, all significant urban land areas in the watershed are proposed to be served by sanitary sewers by the year 2000. In addition, as of 1975, an estimated 20 privately owned onsite sewage disposal systems—14 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the direct tributary lake watershed area.

## Table C-150

## WATER QUALITY MANAGEMENT MEASURES FOR LITTLE CEDAR LAKE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 9,300 | $ 800 | $ 7,000 | $ 9,400 | $ 16,400 | $ 400 | $ 600 | $ 1,000 | | |
| Minimum Rural Conservation Practices | 300 | 2,500 | 200 | 30,000 | 30,200 | <100 | 1,900 | 2,000 | | |
| Low Cost Urban Land Management Practices | Mimimum | 500 | Minimum | 7,600 | 7,600 | Minimum | 500 | 500 | | |
| Total | 9,600 | 3,800 | 7,200 | 47,000 | 54,200 | 500 | 3,000 | 3,500 | | 75 |
| Hypolimnetic Aeration[b] | 18,200 | 500 | 13,600 | 7,900 | 21,500 | 900 | 500 | 1,400 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[c] | 9,100 to 24,600 | -- | 6,800 to 18,400 | -- | 6,800 to 18,400 | 400 to 1,200 | -- | 400 to 1,200 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[d,e] | 492,000 | -- | 367,700 | -- | 367,700 | 23,300 | -- | 23,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[e,f] | 793,600 | -- | 593,100 | -- | 593,100 | 37,600 | -- | 37,600 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Little Cedar Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Little Cedar Lake drainage basin include a capital cost over the period of 1975-2000 of $81,000, an average annual operation and maintenance cost of $1,300, and a total 50-year present worth cost of $90,600.*

[b] *Cost estimated to aerate the entire hypolimnion of the lake.*

[c] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[d] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[e] *The costs for sediment covering and dredging may depend on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

[f] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 13 feet.*

*Source: SEWRPC.*

As indicated in Table C-152, all direct tributary sources combined contribute about 140 pounds of phosphorus annually to Lucas Lake. The major direct source of phosphorus in the lake watershed is malfunctioning septic tank systems and runoff from rural land. In addition, approximately 100 pounds of phosphorus are contributed annually from the drainage from Silver Lake. Although the provision of sanitary sewer service is not recommended for Lucas Lake, it is recommended that a septic tank system management program be undertaken to locate and correct those systems which are malfunctioning. Also, as indicated in Table C-152, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from septic tank systems and rural land uses may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.03 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth for the maintenance of a warmwater fishery and recreational use classification. Anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lucas Lake which meet the recommended level for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-153, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: improved septic tank management; minimum measures to reduce pollutant runoff from rural

## Table C-151

## GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LUCAS LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 78 acres |
| Direct Tributary Drainage Area | 484 acres |
| Shoreline | 2.39 miles |
| Depth | |
| Maximum | 15 feet |
| Mean | 6 feet |
| Volume | 461 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 69 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; moderate macrophyte growth; low to moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.46 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-152

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LUCAS LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 90 | 13 | 9.1 | 90 | 13 | 9.3 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 14 | 41 | 28.7 | 13 | 38 | 27.1 |
| Rural Land Cover (acres) | 394 | 50 | 34.9 | 394 | 50 | 35.7 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 78 | 39 | 27.3 | 78 | 39 | 27.9 |
| Total | – | 143[c] | 100.0 | – | 140[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

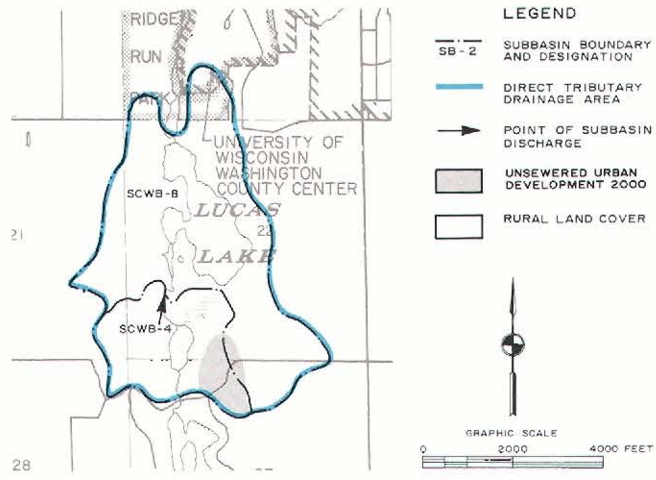
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 100 pounds per year or the year 2000 load of 50 pounds of phosphorus per year contributed by the upstream Silver Lake outlet.*

*Source: SEWRPC.*

## Map 51

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LUCAS LAKE: 2000




Lucas Lake has a direct tributary drainage area of about 484 acres. About 394 acres, or 81 percent of the drainage area, are planned to be in rural land cover, and 90 acres, or 19 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

lands through the implementation of basic soil conservation practices; and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-153 may include dredging, sediment covering, total aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lucas Lake requires that the recommended level of nutrient input reductions be achieved.

## Table C-153

## WATER QUALITY MANAGEMENT MEASURES FOR LUCAS LAKE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ 100 | $ 700 | $ 100 | $ 8,400 | $ 8,500 | $ 100 | $ 500 | $ 600 | | |
| Low Cost Urban Land Management Practices | Minimum | 100 | Minimum | 1,100 | 1,100 | Minimum | <100 | <100 | | |
| Total | 100 | 800 | 100 | 9,500 | 9,600 | <100 | 600 | 700 | | 35[h] |
| Macrophyte Harvesting[b] | 28,000 | 3,900 | 20,900 | 61,500 | 82,400 | 1,300 | 3,900 | 5,200 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[c] | 6,000 | 200 | 4,500 | 3,200 | 7,700 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 7,800 | – | 5,800 | – | 5,800 | 400 | – | 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 156,000 | – | 116,600 | – | 116,600 | 7,400 | – | 7,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 1,132,300 | – | 846,200 | – | 846,200 | 53,700 | – | 53,700 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lucas Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lucas Lake drainage basin include a capital cost over the period of 1975-2000 of $54,000, an average annual operation and maintenance cost of $600, and a total 50-year present worth cost of $51,100.*

[b] *Cost estimated to harvest macrophytes from the 30 acres of Lucas Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the 30 acres of the lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs of sediment covering and dredging may be higher depending upon such factors as lake depth, lake size, characteristics of bottom substrate, etc.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 6 feet.*

[h] *The reduction in the direct phosphorus load to Lucas Lake must be augmented by the implementation of minimum practices in the upstream drainage area of Silver Creek if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Lucas Lake is to meet the water quality criteria for recreation and warmwater fishery.*

*Source: SEWRPC.*

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lucas Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $800. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $9,600, with an equivalent annual cost of $700. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $6,000 for total aeration to $1,132,300 for dredging. The total present worth of these rehabilitation measures would range from $5,800 for nutrient inactivation to $846,200 for dredging.

Mud Lake

Mud Lake is a 245-acre lake located in the Town of Saukville in Ozaukee County. Mud Lake drains in a southwesterly direction into Lower Cedar Creek.

Certain geomorphological characteristics of Mud Lake are set forth in Table C-154, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-52 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-52, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 55 privately owned onsite sewage disposal systems—12 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-155, all sources combined contribute about 4,500 pounds of phosphorus annually to Mud Lake. The major source of phosphorus in the lake watershed is runoff from livestock operations. Also, as indicated in Table C-155, the existing land uses are not

### Table C-154

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF MUD LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 245 acres |
| Direct Tributary Drainage Area | 4,233 acres |
| Shoreline | 3.9 miles |
| Depth | |
| Maximum | 4 feet |
| Mean | 2.5 feet |
| Volume | 645 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 205 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; frequent fish winterkill; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.72 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Table C-155

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO MUD LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 123 | 52 | 1.2 | 123 | 52 | 1.2 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 12 | 35 | 0.8 | 12 | 35 | 0.8 |
| Rural Land Cover (acres) | 4,110 | 399 | 8.9 | 4,110 | 399 | 8.9 |
| Livestock Operations (animal units) | 583 | 3,848 | 86.3 | 583 | 3,848 | 86.3 |
| Atmospheric Contribution (acres of receiving surface water) | 245 | 123 | 2.8 | 245 | 123 | 2.8 |
| Total | – | 4,457 | 100.0 | – | 4,457 | 100.0 |

[a] *Assumes no nonpoint source control.*

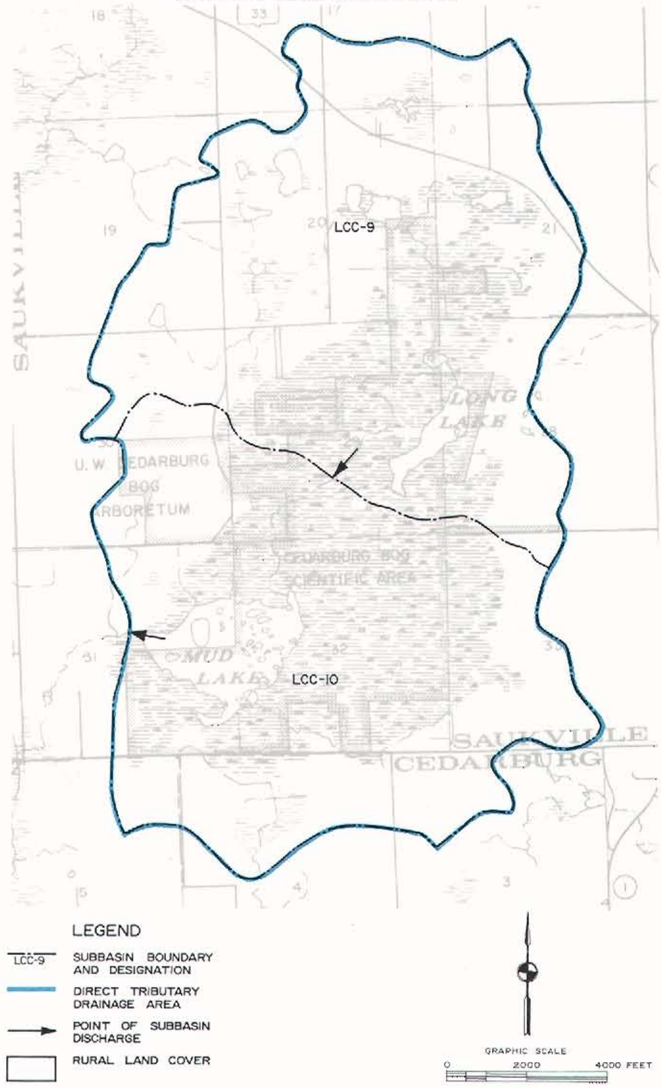
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock operations may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring mixing under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.18 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l of total phosphorus to limit nuisance algae and weed growth to minimum level and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Mud Lake which exceed the recommended level necessary to maintain water quality suitable for recreational use and for the maintenance of a warmwater fishery. Because of the large drainage area and physical limitations of the lake basin, specifically its shallow depth and resulting annual winter fishkill, Mud Lake has a naturally advanced eutrophic state and cannot realistically achieve a water quality suitable for a productive warmwater fishery. Minimal nonpoint source control measures

### Map C-52

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF MUD LAKE: 2000




Mud Lake has a direct tributary drainage area of about 4,233 acres. About 4,110 acres, or 97 percent of the drainage area, are planned to be in rural land cover, and 123 acres, or 3 percent, to be in urban land cover. Over the planning period none of the direct tributary drainage watershed area is expected to be converted to urban land cover. To provide water quality protection, minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program, should be implemented.

*Source: SEWRPC.*

should be implemented, however, to maintain the current predominately natural state of Mud Lake. This should allow limited recreational use and limited objectives fishery to be achieved. Given the current condition of the lake, expensive nonpoint source control measures are probably not warranted.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-156, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

Because of Mud Lake's limited fishery and limited recreational use objective, the designation of the majority of the bog area as a Wildlife and Scientific Area by the Wisconsin Department of Natural Resources, and the extensive use and partial ownership of the area by The University of Wisconsin-Milwaukee for a natural wildlife and ecological study area, the lake should be protected in its natural eutrophic state. Therefore, only those pollutant control measures that can be applied to the human related pollution sources in the watershed land area, i.e., livestock control, septic tank management, low cost urban land management practices, and basic conservation practices applied to the rural land acreage, should be implemented. Any inland lake rehabilitation measures such as hypolimnetic aeration, nutrient inactivation, sediment covering, or dredging are not consistent with the current use of Mud Lake and are therefore not recommended.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Mud Lake would entail a total capital cost of about $52,100, and an average annual operation and maintenance cost of about $11,800. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $181,200, with an equivalent annual cost of $11,600.

Silver Lake

Silver Lake is an 118-acre lake located in the Town of West Bend in Washington County. The lake drains to Silver Creek. Certain geomorphological characteristics of Silver Lake are set forth in Table C-157, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-53 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-53, none of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 136 privately owned onsite sewage disposal systems—110 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.[15]

[15] *The provision of sanitary sewer service to the lake watershed was proposed in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin. However, field studies conducted by the Wisconsin Department of Natural Resources have demonstrated that sanitary sewer service is probably not required if proper septic tank system maintenance is assured. As presented in the point source element discussion in Chapter 4 of this Volume, sanitary sewer service is no longer recommended for the Silver Lake watershed.*

**Table C-156**

**WATER QUALITY MANAGEMENT MEASURES FOR MUD LAKE IN OZAUKEE COUNTY**

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Present Worth: 1975-2025: Capital | Present Worth: 1975-2025: Operation and Maintenance | Present Worth: 1975-2025: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: 1975-2025: Operation and Maintenance | Equivalent Annual: 1975-2025: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 51,300 | $ 4,400 | $ 38,400 | $ 51,500 | $ 89,900 | $ 2,400 | $ 3,300 | $ 5,700 | | |
| Minimum Rural Conservation Practices | 800 | 7,200 | 600 | 87,700 | 88,300 | < 100 | 5,600 | 5,700 | | |
| Low Cost Urban Land Management Practices | Minimum | 200 | Minimum | 3,000 | 3,000 | Minimum | 200 | 200 | | |
| Total | 52,100 | 11,800 | 39,000 | 142,200 | $ 181,200 | 2,500 | 9,100 | 11,600 | | 85 |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Mud Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Mud Lake drainage basin include a capital cost over the period of 1975-2000 of $54,000, an average annual operation and maintenance cost of $1,800, and a total 50-year present worth cost of $90,000.*

*Source: SEWRPC.*

Table C-157

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SILVER LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 118 acres |
| Direct Tributary Drainage Area | 602 acres |
| Shoreline | 2.74 miles |
| Depth | |
| Maximum | 47 feet |
| Mean | 20 feet |
| Volume | 2,306 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 471 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; low nutrient concentrations; generally good water quality |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.46 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-158

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SILVER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 118 | 12 | 4.2 | 118 | 12 | 4.2 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 110 | 159 | 55.8 | 110 | 159 | 55.8 |
| Rural Land Cover (acres) | 484 | 27 | 9.5 | 484 | 27 | 9.5 |
| Livestock Operations (animal units) | 42 | 28 | 9.8 | 42 | 28 | 9.8 |
| Atmospheric Contribution (acres of receiving surface water) | 118 | 59 | 20.7 | 118 | 59 | 20.7 |
| Total | – | 285[c] | 100.0 | – | 285[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

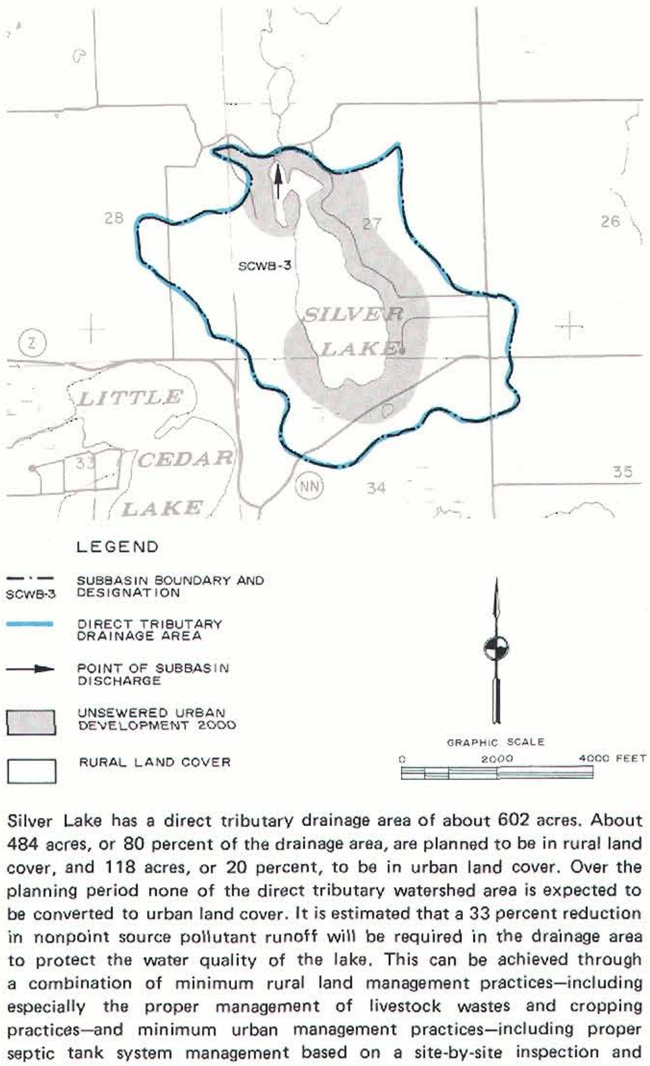
[c] *Includes phosphorus loads from groundwater. The lake study conducted by the Wisconsin Department of Natural Resources indicated that groundwater phosphorus loads, which may be contributed from natural sources, land surface seepage, and outlying septic systems, are higher than direct septic system phosphorus loads to the lake.*

*Source: SEWRPC.*

As indicated in Table C-158, based on Wisconsin Department of Natural Resources field study results, water quality simulation analyses, and phosphorus loading estimates, all direct tributary sources combined contribute about 285 pounds of phosphorus annually to Silver Lake. The major source of phosphorus in the lake watershed is septic tank systems. Urban land uses in the lake watershed are not expected to increase under planned year 2000 land cover conditions, and annual total phosphorus loadings to the lake are expected to remain constant if pollutant controls are not implemented. While no significant construction activities should occur within the lake watershed through the year 2000, it must be recognized that if such activities do occur, the potential for excessive pollutant contributions to the lake from these activities exists and effective control measures should accordingly be implemented to avoid these excessive contributions. The estimated total phosphorus concentration during spring overturn under both existing and anticipated year 2000 conditions, as estimated from Wisconsin Department of Natural Resources field study results, water quality model simulation analyses, and phosphorus loading estimates, is 0.03 milligram per liter (mg/l). The Commission recomends a level of 0.02 mg/l or less of total phosphorus for the prevention of exces-

Map C-53

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SILVER LAKE: 2000




Silver Lake has a direct tributary drainage area of about 602 acres. About 484 acres, or 80 percent of the drainage area, are planned to be in rural land cover, and 118 acres, or 20 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes and cropping practices—and minimum urban management practices—including proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

sive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in a total phosphorus concentration in Silver Lake which slightly exceeds the recommended level for recreational use and for maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-159, along with the associated costs and anticipated effectiveness. Measures to control septic tank system contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other recommended measures include: livestock waste management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-159 may include sediment covering aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Silver Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Silver Lake would entail a total capital cost of about $3,800, and an average annual operation and maintenance cost of about $1,400. The total 50-year present worth cost of these source control measures is $19,900 with an equivalent annual cost of $1,400. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $6,600 for nutrient inactivation to $236,000 for sediment covering. The total present worth of these rehabilitation measures ranges from $4,900 for nutrient inactivation to $176,400 for dredging.

Smith Lake

Smith Lake is an 86-acre lake located in the Town of Barton in Washington County. Smith Lake drains to the west to the mainstream of the Milwaukee

**Table C-159**

**WATER QUALITY MANAGEMENT MEASURES FOR SILVER LAKE IN WASHINGTON COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 30 |
| Livestock Waste Control | $ 3,700 | $ 300 | $ 2,800 | $ 3,700 | $ 6,500 | $ 200 | $ 200 | $ 400 | | |
| Minimum Rural Conservation Practices | 100 | 900 | 100 | 10,400 | 10,500 | 100 | 700 | 800 | | |
| Low Cost Urban Land Management Practices | Minimum | 200 | Minimum | 2,900 | 2,900 | Minimum | 200 | 200 | | |
| Total | 3,800 | 1,400 | 2,900 | 17,000 | 19,900 | 300 | 1,100 | 1,400 | | |
| Hypolimnetic Aeration[b] | 13,200 | 300 | 9,900 | 4,700 | 14,600 | 600 | 300 | 900 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[c] | 6,600 to 11,800 | – | 4,900 to 8,800 | – | 4,900 to 8,800 | 300 to 600 | – | 300 to 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[d,e] | 236,000 | – | 176,400 | – | 176,400 | 11,200 | – | 11,200 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Silver Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Silver Lake drainage basin include a capital cost over the period of 1975-2000 of $495,000, an average annual operation and maintenance cost of $5,200, and a total 50-year present worth cost of $457,800.*

[b] *Cost estimated to aerate the entire hypolimnion of the lake.*

[c] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[d] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[e] *The costs of sediment covering will vary widely depending upon such factors as lake size, lake depth, type of substrate being covered, and amount of fill or material necessary.*

*Source: SEWRPC.*

River via an unnamed intermittent tributary. Certain geomorphological characteristics of Smith Lake are set forth in Table C-160, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-54 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality management plan. The delineated tributary drainage area should be refined in a more detailed local lake study. As shown on Map C-54, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 21 privately owned onsite sewage disposal systems—eight of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the watershed area.

As indicated in Table C-161, all sources combined contribute about 1,200 pounds of phosphorus annually to Smith Lake. The major source of phosphorus in the lake watershed is runoff from livestock operations. Also as indicated in Table C-161, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loading from livestock operations may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.15 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Smith Lake which exceed the recommended level for recreational use and maintenance of a warmwater fishery.

Table C-160

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SMITH LAKE

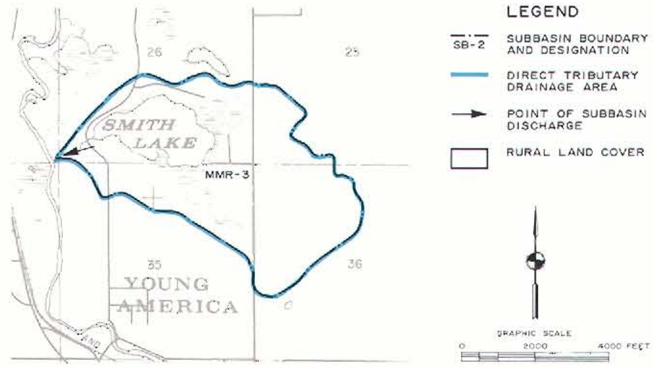
| Characteristic | Description |
|---|---|
| Surface Area | 86 acres |
| Direct Tributary Drainage Area | 545 acres |
| Shoreline | 1.8 miles |
| Depth: Maximum | 5 feet |
| Depth: Mean | 3 feet |
| Volume | 252 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 73 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; frequent fish winterkill; moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.46 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-54

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SMITH LAKE: 2000




Smith Lake has a direct tributary drainage area of about 545 acres. About 523 acres, or 96 percent of the drainage area, are planned to be in rural land cover, and 22 acres, or 4 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-161

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SMITH LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 22 | 3 | 0.3 | 22 | 3 | 0.3 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 8 | 23 | 1.9 | 8 | 23 | 1.9 |
| Rural Land Cover (acres) | 523 | 53 | 4.5 | 523 | 53 | 4.5 |
| Livestock Operations (animal units) | 161 | 1,063 | 89.7 | 161 | 1,063 | 89.7 |
| Atmospheric Contribution (acres of receiving surface water) | 86 | 43 | 3.6 | 86 | 43 | 3.6 |
| Total | – | 1,185 | 100.0 | – | 1,185 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-162, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above nonpoint source controls. Alternative restoration measures as set forth in Table C-162 may include dredging, sediment covering, aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Smith Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Smith Lake would entail a total capital cost of about $14,300, and an average annual operation and maintenance cost of about $2,200. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $36,600, with an equivalent annual

**Table C-162**

**WATER QUALITY MANAGEMENT MEASURES FOR SMITH LAKE IN WASHINGTON COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 14,200 | $ 1,200 | $ 10,600 | $ 14,200 | $ 24,800 | $ 1,700 | $ 900 | $ 2,600 | | |
| Minimum Rural Conservation Practices | 100 | 900 | <100 | 11,200 | 11,300 | <100 | 700 | 800 | | |
| Low Cost Urban Land Management Practices | Minimum | <100 | Minimum | 500 | 500 | Minimum | <100 | <100 | | |
| Total | 14,300 | 2,200 | 10,700 | 25,900 | 36,600 | 1,800 | 1,700 | 3,500 | | 85 |
| Macrophyte Harvesting[b] | 28,000 | 3,900 | 20,900 | 61,500 | 82,400 | 1,300 | 3,900 | 5,200 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[c] | 17,200 | 400 | 12,900 | 6,300 | 19,200 | 800 | 400 | 1,200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 8,600 | – | 6,400 | – | 6,400 | 400 | – | 400 | Accelerate lake improvement; prevent release of nutrients from sediment, remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 172,000 | – | 128,500 | – | 128,500 | 8,200 | – | 8,200 | Accelerate lake improvement; prevent release of nutrients from sediment, reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 1,664,600 | – | 1,244,000 | – | 1,244,000 | 78,900 | – | 78,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Smith Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Smith Lake drainage basin include a capital cost over the period of 1975-2000 of $36,000, an average annual operation and maintenance cost of $700, and a total 50-year present worth cost of $44,400.*

[b] *Cost estimated to harvest macrophytes from the 30 acres of Smith Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs for dredging and sediment covering vary widely depending upon such factors as depth, size and type of bottom material, and the amount of material to be dredged or filled.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 3 feet.*

*Source: SEWRPC.*

cost of $3,500. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $8,600 for nutrient inactivation to $1,664,600 for dredging. The total present worth of these rehabilitation measures would range from $6,400 for nutrient inactivation to $1,244,000 for dredging.

Spring Lake

Spring Lake is a 57-acre lake located in the Town of Fredonia in Ozaukee County and the Town of Sherman in Sheboygan County. Spring Lake drains to the north to Random Lake which eventually drains to the North Branch of the Milwaukee River via Silver Creek (Sheboygan County). Certain geomorphological characteristics of Spring Lake are set forth in Table C-163, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-55 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-55, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated three privately owned onsite sewage disposal systems—two of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-164, all sources combined contribute about 50 pounds of phosphorus annually to Spring Lake. The major source of phosphorus in the lake watershed is runoff from rural land. Also as indicated in Table C-164, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from atmospheric fallout and rural land runoff may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.01 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance

Table C-163

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SPRING LAKE

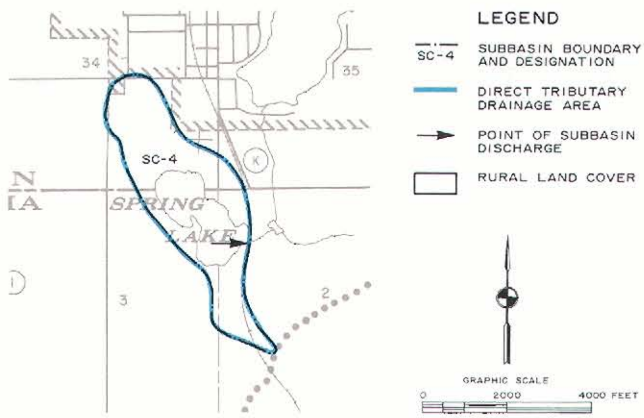
| Characteristic | Description |
|---|---|
| Surface Area | 57 acres |
| Direct Tributary Drainage Area | 162 acres |
| Shoreline | 1.6 miles |
| Depth | |
| Maximum | 22 feet |
| Mean | 7 feet |
| Volume | 415 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 11 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; low to moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.8 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-55

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SPRING LAKE: 2000




Spring Lake has a direct tributary drainage area of about 162 acres. The entire drainage area is planned to be in rural land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, minimum rural land management practices and septic system management should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-164

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SPRING LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | – | – | – | – | – | – |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | less than 5 | 6 | 12.0 | less than 5 | 6 | 12.0 |
| Rural Land Cover (acres) | 162 | 15 | 30.0 | 162 | 15 | 30.0 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 57 | 29 | 58.0 | 57 | 29 | 58.0 |
| Total | – | 50 | 100.0 | – | 50 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Spring Lake which are below the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-165, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: improved septic tank management and minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-165 may include dredging, sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be addressed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Spring Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Spring Lake would entail a total capital cost of less than $100, and an average annual operation and maintenance cost of about $300. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $3,600, with an equivalent annual cost of $300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $2,000 for hypolimnetic aeration to $735,500 for dredging. The total present worth costs of these lake rehabilitation measures would range from $2,400 for hypolimnetic aeration to $549,700 for dredging.

<u>Lake Twelve</u>

Lake Twelve is a 53-acre lake located in the Town of Farmington in Washington County. Lake Twelve drains in a westward direction to the North Branch of the Milwaukee River. Certain geomorphological characteristics of Lake Twelve are set forth in Table C-166, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-56 presents a graphic

**Table C-165**

**WATER QUALITY MANAGEMENT MEASURES FOR SPRING LAKE IN OZAUKEE COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Minimum Rural Conservation Practices | $ < 100 | $ 300 | $ < 100 | $ 3,500 | $ 3,600 | $ < 100 | $ 200 | $ 300 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 10 |
| Total | < 100 | 300 | < 100 | 3,500 | 3,600 | < 100 | 200 | 300 | | |
| Hypolimnetic Aeration[a] | 2,000 | 50 | 1,500 | 800 | 2,400 | 100 | 100 | 200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[b] | 5,700 | -- | 4,300 | -- | 4,300 | 300 | -- | 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[c,d] | 114,000 | -- | 85,200 | -- | 85,200 | 5,400 | -- | 5,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[d,e] | 735,500 | -- | 549,700 | -- | 549,700 | 34,900 | -- | 34,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *Cost estimated to aerate the 10 acres of the hypolimnion of the lake.*

[b] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[c] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[d] *The costs for dredging and sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

[e] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 7 feet.*

*Source: SEWRPC.*

Table C-166

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE TWELVE

| Characteristic | Description |
|---|---|
| Surface Area | 53 acres |
| Direct Tributary Drainage Area | 348 acres |
| Shoreline | 1.3 miles |
| Depth | |
| Maximum | 20 feet |
| Mean | 7 feet |
| Volume | 341 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 51 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.63 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

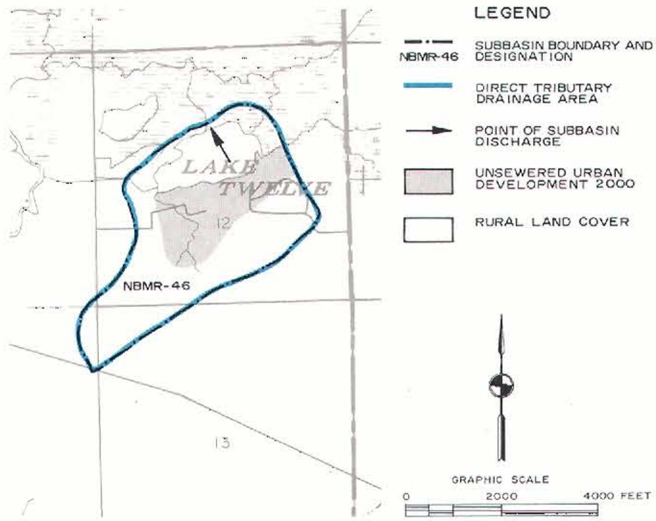
*Source: SEWRPC.*

summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-56, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, estimated 14 privately owned onsite sewage disposal systems—seven of which are located in areas covered by soils having severe and very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-167, all sources combined contribute about 175 pounds of phosphorus annually to Lake Twelve. The major source of phosphorus in the lake watershed is runoff from rural and urban land. Also as indicated in Table C-167, the existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from rural and urban land uses may be expected to continue to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.04 milligram per liter (mg/l). The Commission recommends a level of 0.02 or less mg/l of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Twelve which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Map C-56

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE TWELVE: 2000




Lake Twelve has a direct tributary drainage area of about 348 acres. About 164 acres, or 47 percent of the drainage area, are planned to be in rural land cover, and 184 acres, or 53 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 50 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-167

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE TWELVE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 184 | 62 | 35.4 | 184 | 62 | 35.4 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 7 | 20 | 11.4 | 7 | 20 | 11.4 |
| Rural Land Cover (acres) | 164 | 67 | 38.3 | 164 | 67 | 38.3 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 53 | 26 | 14.9 | 53 | 26 | 14.9 |
| Total | – | 175 | 100.0 | – | 175 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, together with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-168, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: improved septic tank management, measures to reduce pollutant runoff from rural lands by 75 percent, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the abovementioned nonpoint source controls. Alternative restoration measures as set forth in Table C-168 may include dredging, sediment covering, aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Lake Twelve requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lake Twelve would entail a total capital cost of about $19,500, and an average annual operation and maintenance cost of about $2,700. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is $31,900, with an equivalent annual cost of $2,000. If in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $5,300 for nutrient inactivation to $598,400 for dredging. The total present worth for these lake rehabilitation measures would range from $4,000 for nutrient inactivation to $447,200 for dredging.

Wallace Lake

Wallace Lake is a 52-acre lake located in the Town of Trenton in Washington County. The lake drains to the North Branch of the Milwaukee River. Certain geomorphological characteristics of Wallace Lake are set forth in Table C-169, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-57 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-57, all significant urban land areas

Table C-168

WATER QUAILITY MANAGEMENT MEASURES FOR LAKE TWELVE IN WASHINGTON COUNTY

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Septic Tank System Management[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth: improve recreational use potential | |
| Rural Conservation Practices[b] | $ 19,500 | $ 2,500 | $ 16,400 | $ 12,800 | $ 29,200 | $ 1,000 | $ 800 | $ 1,800 | | |
| Low Cost Urban Land Management Practices | Minimum | 200 | Minimum | 2,700 | 2,700 | Minimum | 200 | 200 | | |
| Total | 19,500 | 2,700 | 16,400 | 15,500 | 31,900 | 1,000 | 1,000 | 2,000 | | 50 |
| Aeration[c] | 10,600 | 300 | 7,900 | 4,700 | 12,600 | 500 | 300 | 800 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 5,300 | -- | 4,000 | -- | 4,000 | 300 | -- | 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 106,000 | -- | 79,200 | -- | 79,200 | 5,000 | -- | 5,000 | Accelerate lake improvement; prevent release of nutrients from sediment, reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 598,400 | -- | 447,200 | -- | 447,200 | 28,400 | -- | 28,400 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Twelve. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Twelve drainage basin include a capital cost over the period of 1975-2000 of $31,500, an average annual operation and maintenance cost of $500, and a total 50-year present worth cost of $34,500.*

[b] *Rural land management practices necessary to achieve 75 percent reduction in rural diffuse source pollutant loads which include the costs for minimum rural land management practices.*

[c] *Cost estimated to aerate the entire lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs for dredging and sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 7 feet.*

*Source: SEWRPC.*

Table C-169

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF WALLACE LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 52 acres |
| Direct Tributary Drainage Area | 282 acres |
| Shoreline | 1.5 miles |
| Depth | |
| Maximum | 35 feet |
| Mean | 11 feet |
| Volume | 558 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 300 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; moderate macrophyte growth; high nutrient concentrations; hypolimnion void of oxygen at times during summer and severe winter months |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.46 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

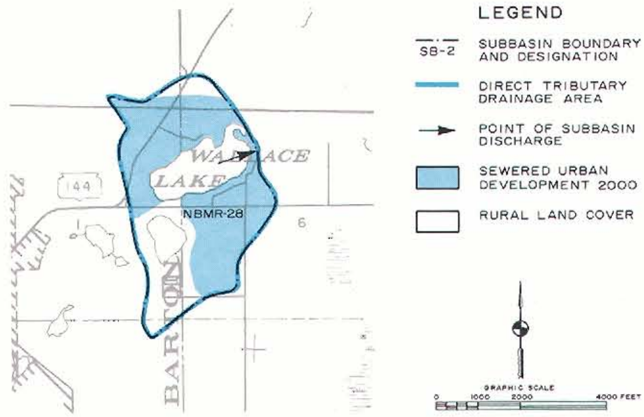
*Source: SEWRPC.*

in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 87 privately owned onsite sewage disposal systems—57 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-170, all sources combined contribute about 200 pounds of phosphorus annually to Wallace Lake. The major source of phosphorus in the lake watershed is malfunctioning septic tanks. Also, as indicated in Table C-170, urban land uses in the watershed are expected to increase by about 200 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to increase to about 600 pounds as a result of urban development. Loadings from the construction activities are expected to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.05 milligram per liter (mg/l) and 0.13 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result

Map C-57

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF WALLACE LAKE: 2000




Wallace Lake has a direct tributary drainage area of about 282 acres. None of the drainage area is planned to be in rural land cover. Over the planning period an average of about 10 acres may be expected to be converted annually to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-170

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO WALLACE LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 81 | 14 | 6.3 | 272 | 82 | 13.6 |
| Land under Development—Construction Activities (acres) | – | – | – | 10 | 458 | 76.2 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 57 | 162 | 73.0 | 12 | 35 | 5.8 |
| Rural Land Cover (acres) | 201 | 20 | 9.0 | – | – | – |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 52 | 26 | 11.7 | 52 | 26 | 4.4 |
| Total | – | 222 | 100.0 | – | 601 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

in total phosphorus concentrations in Wallace Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-171, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: the provision of sanitary sewer service, improved septic tank management, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the above point and nonpoint source controls. Alternative restoration measures as set forth in Table C-171 may include dredging, sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Wallace Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Wallace Lake would entail a total capital cost of about $462,000, and an average annual operation and maintenance cost of about $4,300. The total 50-year present worth cost of these nonpoint source control measures is $414,200, with an equivalent annual cost of $26,300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $1,000 for nutrient inactivation to $335,500 for

Table C-171

WATER QUALITY MANAGEMENT MEASURES FOR WALLACE LAKE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[a,b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentration | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Construction Erosion Control Practices[d] | $ 462,000 | $ 4,000 | $ 346,800 | $ 63,100 | $ 409,900 | $ 22,000 | $ 4,000 | $ 26,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 300 | Minimal | 4,300 | 4,300 | Minimal | 300 | 300 | | |
| Total | 462,000 | 4,300 | 346,800 | 67,400 | 414,200 | 22,000 | 4,300 | 26,300 | | 85 |
| Macrophyte Harvesting[e] | 18,600 | 2,600 | 13,900 | 41,000 | 54,900 | 900 | 2,600 | 3,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 19,000 | <100 | 1,400 | 1,600 | 3,000 | 100 | 100 | 200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 1,000 to 5,200 | – | 700 to 3,900 | – | 700 to 3,900 | <100 to 200 | – | <100 to 200 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 104,000 | – | 77,700 | – | 77,700 | 4,900 | – | 4,900 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[i,j] | 335,500 | – | 250,700 | – | 250,700 | 15,900 | – | 15,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Upper Milwaukee River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Upper Milwaukee River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Wallace Lake drainage basin include a capital cost over the period of 1975-2000 of $1,030,100, an average annual operation and maintenance cost of $7,700, and a total 50-year present worth cost of $698,900.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Wallace Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Wallace Lake drainage basin include a capital cost over the period of 1975-2000 of $157,500, an average annual operation and maintenance cost of $1,500, and a total 50-year present worth cost of $138,400.*

[d] *Cost estimated to control erosion from the estimated 10 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 20 acres of Wallace Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 11 feet.*

[j] *The costs of dredging and sediment covering may vary widely depending upon such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

dredging. The total present worth costs of these lake rehabilitation measures would range from $700 for nutrient inactivation to $250,700.

West Bend Pond

West Bend Pond is a 67-acre lake located in the City of West Bend in Washington County. The lake is a single-basin impoundment of the mainstem of the Milwaukee River. Certain geomorphological characteristics of West Bend Pond are set forth in Table C-172, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-58 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-58 are significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 11 privately owned onsite sewage disposal systems—none of which are located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-173, all sources combined contribute about 400 pounds of phosphorus annually to West Bend Pond. The major sources of phosphorus in the lake watershed are construction activities and urban land uses. Additionally, about 12,600 pounds of phosphorus are contriubted annually from the large upstream area tributary to the West Bend Pond. As indicated in Table C-173, urban land uses in the watershed are expected to increase only slightly—by about 4 percent—under planned

Table C-172

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF WEST BEND POND

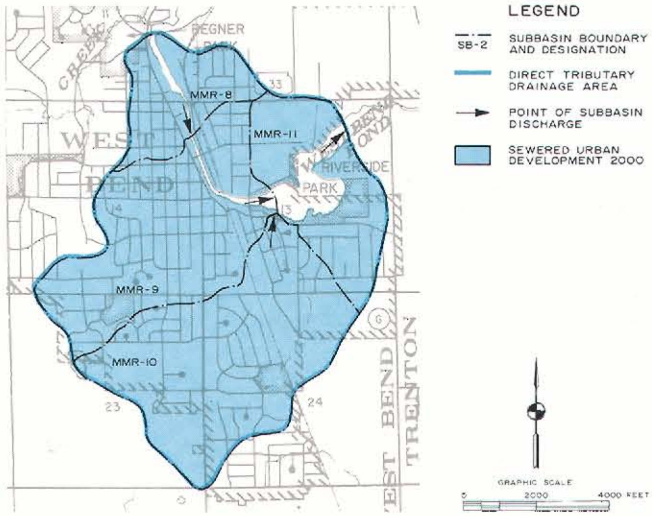
| Characteristic | Description |
|---|---|
| Surface Area | 67 acres |
| Direct Tributary Drainage Area | 897 acres |
| Shoreline | 2.7 miles |
| Depth | |
| Maximum | 14 feet |
| Mean | 6 feet |
| Volume | 427 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 8,089 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; locations of dense macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.46 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-58

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF WEST BEND POND: 2000




West Bend Pond has a direct tributary drainage area of about 897 acres. About 254 acres, or 28 percent of the drainage area, are planned to be in rural land cover, and 642 acres, or 72 percent, to be in urban land cover. Over the planning period an average of about one acre may be expected to be converted annually to urban land cover. It is estimated that a 50 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the pond. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices, and construction erosion controls.

*Source: SEWRPC.*

Table C-173

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO WEST BEND POND: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 619 | 279 | 71.7 | 642 | 290 | 73.0 |
| Land under Development–Construction Activities (acres) | 1 | 45 | 11.6 | 1 | 45 | 11.3 |
| Onsite Sewage Disposal Septic Tank Systems[b] | – | – | – | – | – | – |
| Rural Land Cover (acres) | 277 | 31 | 8.0 | 254 | 28 | 7.1 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 67 | 34 | 8.7 | 67 | 34 | 8.6 |
| Total | – | 389[c] | 100.0 | – | 397[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 12,580 pounds per year or the year 2000 anticipated phosphorus load of 4,647 pounds per year, contributed from the large upstream portion of the Milwaukee River Watershed.*

*Source: SEWRPC.*

year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to remain about the same. Loadings from the construction activities needed for the development of urban land are expected to be the primary source of phosphorus to the lake under anticipated year 2000 conditions. In addition, approximately 4,700 pounds of phosphorus will be contriubted annually following a 25 percent reduction in total phosphorus by the implementation of various nonpoint source control measures and substantial point source reductions in the upstream tributary watershed area. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.05 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in West Bend Pond which exceed and meet, respectively the recommended level for recreational use and for the maintenance of a limited fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-174, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited

Table 174

WATER QUALITY MANAGEMENT MEASURES FOR WEST BEND POND IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Minimum Rural Conservation Practices | $ 100 | $ 300 | $ <100 | $ 3,500 | $ 3,600 | $ 100 | $ 200 | $ 300 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Construction Erosion Control Practices[c] | 415,800 | 3,600 | 312,100 | 56,700 | 368,800 | 19,800 | 3,600 | 23,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,200 | Minimal | 17,700 | 17,700 | Minimal | 1,100 | 1,100 | | |
| Total | 415,900 | 5,100 | 312,200 | 77,900 | 390,100 | 19,900 | 4,900 | 24,800 | | 50 |
| Macrophyte Harvesting[d] | 28,000 | 3,900 | 20,900 | 61,500 | 82,400 | 1,300 | 3,900 | 5,200 | Control excessive macrophyte growth; asethetic enhancement; improve recreational use potential | Minimal additional reduction |
| Nutrient Inactivation[e] | 6,700 | – | 5,000 | – | 5,000 | 300 | – | 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,g] | 134,000 | – | 100,100 | – | 100,100 | 6,400 | – | 6,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 972,600 | – | 726,800 | – | 726,800 | 46,100 | – | 46,100 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Upper Milwaukee River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Upper Milwaukee River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the West Bend Pond drainage basin include a capital cost over the period of 1975-2000 of $4,444,000, an average annual operation and maintenance cost of $103,100, and a total 50-year present worth cost of $4,115,900.*

[c] *Cost estimated to control erosion from the estimated nine acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[d] *Cost estimated to harvest macrophytes from the 30 acres of West Bend Pond subject to excessive macrophyte growth.*

[e] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *The costs for dredging and sediment covering may vary widely depending upon such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

[h] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 6 feet.*

*Source: SEWRPC.*

on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-174 may include sediment covering, nutrient inactivation, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in West Bend Pond requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient input to West Bend Pond would entail a total capital cost of about $415,900, and an average annual operation and maintenance cost of about $5,100. The total 50-year present worth cost of these nonpoint source control measures is $390,100, with an equivalent annual cost of $24,800. If, in addition, rehabilitation techniques are found necessary, the capital costs of these alternatives would range from $6,700 for nutrient inactivation to $972,600 for dredging. The total present worth of these lake rehabilitation costs would range from $5,000 for nutrient inactivation to $726,800 for dredging.

## ROCK RIVER WATERSHED LAKES

### Ashippun Lake

Ashippun Lake is an 84-acre lake located in the Town of Oconomowoc in Waukesha County. The lake drains to the Ashippun River. Certain geomorphological characteristics of Ashippun Lake are set forth in Table C-175, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-59 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality management plan. The delineated tributary drainage area should be refined in a more detailed local lake study. As shown on Map C-59, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 56 privately owned onsite sewage disposal systems—20 of which are located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-176, all direct sources combined contribute about 130 pounds of phosphorus annually to Ashippun Lake. The major source of phosphorus in the lake watershed is malfunctioning septic systems. Also, as indicated in Table C-176, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions.

**Table C-175**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF ASHIPPUN LAKE**

| Characteristic | Description |
|---|---|
| Surface Area | 84 acres |
| Direct Tributary Drainage Area | 347 acres |
| Shoreline | 1.50 miles |
| Depth | |
| Maximum | 35.0 feet |
| Mean | 17.1 feet |
| Volume | 1,436 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 179 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth in shallow areas |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

**Table C-176**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO ASHIPPUN LAKE: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 60 | 7 | 5.2 | 60 | 7 | 5.2 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 20 | 58 | 43.4 | 20 | 58 | 43.4 |
| Rural Land Cover (acres) | 287 | 27 | 20.1 | 287 | 27 | 20.1 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 84 | 42 | 31.3 | 84 | 42 | 31.3 |
| Total | – | 134 | 100.0 | – | 134 | 100.0 |

[a] *Assumes no nonpoint source control.*

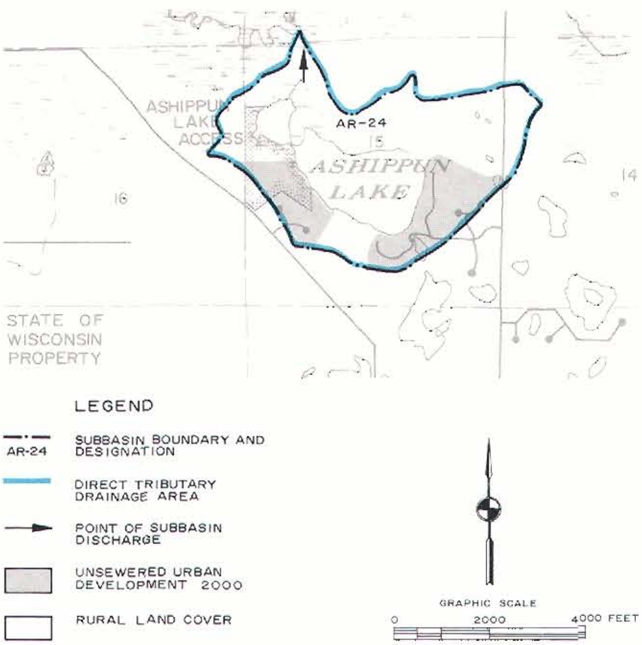
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Ashippun Lake which do not exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Map C-59

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF ASHIPPUN LAKE: 2000**




Ashippun Lake has a direct tributary drainage area of about 347 acres. About 287 acres, or 83 percent of the drainage area, are planned to be in rural land cover, and 60 acres, or 17 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. Certain low-cost control measures are recommended in the Ashippun Lake watershed to ensure continued high quality water. These measures are set forth in Table C-177, along with the associated costs and anticipated effectiveness. Measures to control septic system contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake while protecting public health. Other needed measures include: minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are controlled by the actions noted above, the sediments which have been deposited on the lake bottom may still provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-177 may include dredging of localized portions of the lake. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. The feasibility of restoration measures was assessed in a preliminary engineering study by the Wisconsin Department of Natural Resources. It should be emphasized, however, that the long-term maintenance of water quality in Ashippun Lake requires that the recommended level of nutrient input reduction be achieved.

Table C-177

**WATER QUALITY MANAGEMENT MEASURES FOR ASHIPPUN LAKE IN WAUKESHA COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 40 |
| Minimum Rural Conservation Practices | $ 100 | $ 500 | $ 1,100 | $ 6,100 | $ 7,200 | $ 100 | $ 400 | $ 500 | | |
| Low Cost Urban Land Management Practices | 0 | 100 | 0 | 1,500 | 1,500 | 0 | 100 | 100 | | |
| Total | 100 | 600 | 1,100 | 7,600 | 8,700 | 100 | 500 | 600 | | |
| Macrophyte Harvesting[b] | 21,200 | 3,000 | 15,800 | 47,300 | 63,100 | 1,000 | 3,000 | 4,000 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Localized Dredging | Indeterminate | | Indeterminate | | | Indeterminate | | | | |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Ashippun Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Ashippun Lake drainage basin include a capital cost over the period of 1975-2000 of $90,000, an average annual operation and maintenance cost of $1,900, and a total 50-year present worth cost of $114,400.*

[b] *Cost estimated to harvest macrophytes from the 20 acres of Ashippun Lake subject to excessive macrophyte growth.*

*Source: SEWRPC.*

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Ashippun Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $600. The total 50-year present worth cost of these source control measures is $8,700, with an equivalent annual cost of $600. If, in addition, rehabilitation techniques are found necessary, the capital cost is estimated to be indeterminate for limited dredging to $21,200 for macrophyte harvesting. The total present worth costs of this lake rehabilitation techniques would be indeterminate for limited dredging to $63,100 for macrophyte harvesting.

Bark Lake

Bark Lake is a 65-acre lake located in the Town of Richfield in Washington County. The lake drains to the Bark River. Certain geomorphological characteristics of Bark Lake are set forth in Table C-178, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-60 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-60, none of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 618 privately owned onsite sewage disposal systems—230 of which are located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

**Table C-178**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BARK LAKE**

| Characteristic | Description |
|---|---|
| Surface Area | 65 acres |
| Direct Tributary Drainage Area | 3,315 acres |
| Shoreline | 1.80 miles |
| Depth | |
| Maximum | 34 feet |
| Mean | 12.9 feet |
| Volume | 838 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 2,447 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; some macrophyte growth; high nutrient concentrations; lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.96 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

As indicated in Table C-179, all direct sources combined contribute about 2,200 pounds of phosphorus annually to Bark Lake. The major source of phosphorus in the lake watershed is livestock operations. Also, as indicated in Table C-179, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.15 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Bark Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-180, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, measures to reduce pollutant runoff from rural lands by 75 percent, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation

**Table C-179**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BARK LAKE: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 735 | 203 | 9.3 | 735 | 203 | 9.3 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 230 | 666 | 30.5 | 230 | 666 | 30.5 |
| Rural Land Cover (acres) | 2,580 | 263 | 12.1 | 2,580 | 263 | 12.1 |
| Livestock Operations (animal units) | 154 | 1,016 | 46.6 | 154 | 1,016 | 46.6 |
| Atmospheric Contribution (acres of receiving surface water) | 65 | 32 | 1.5 | 65 | 32 | 1.5 |
| Total | – | 2,180 | 100.0 | – | 2,180 | 100.0 |

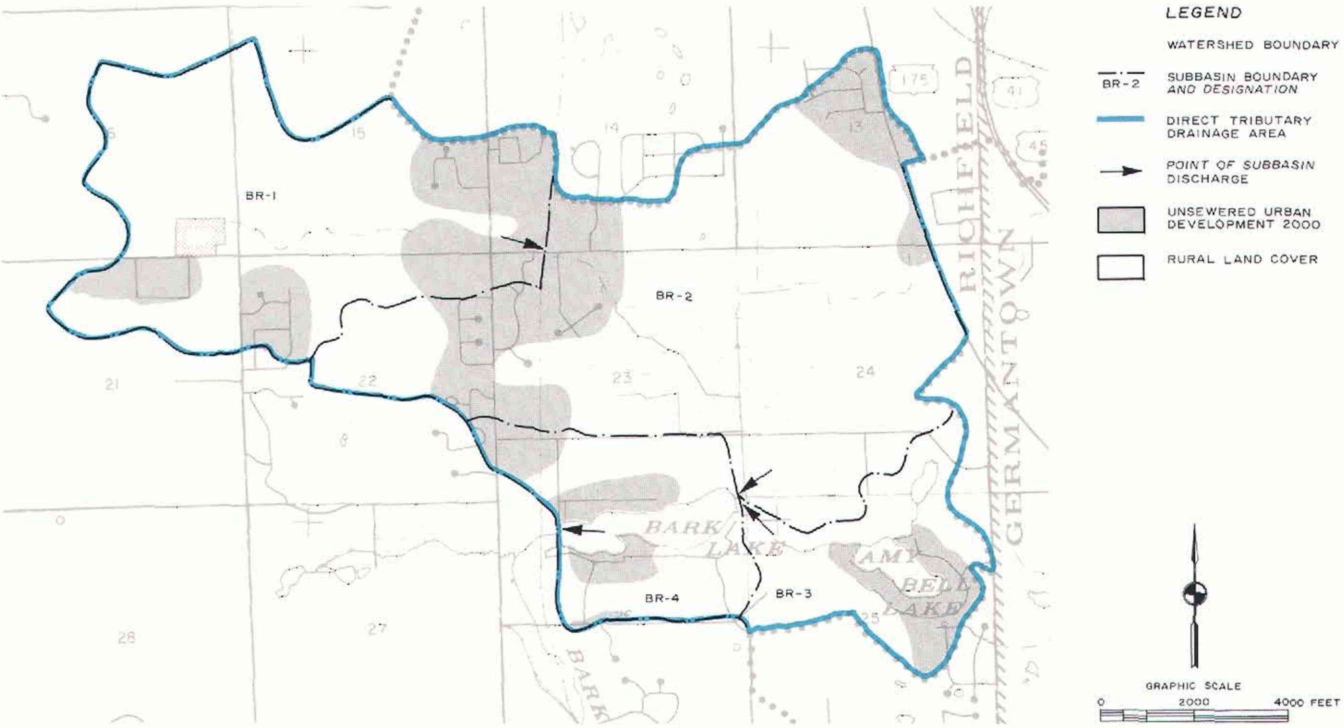
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-60

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF BARK LAKE: 2000




Bark Lake has a direct tributary drainage area of about 3,315 acres. About 2,580 acres, or 78 percent of the drainage area, are planned to be in rural land cover, and 735 acres, or 22 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-180 may include nutrient inactivation, hypolimnetic aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Bark Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Bark Lake would entail a total capital cost of about $320,700, and an average annual operation and maintenance cost of about $42,400. The total 50-year present worth cost of these source control measures is $502,300, with an equivalent annual cost of $31,800. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,400 for hypolimnetic aeration to $220,200 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,800 for nutrient inactivation to $164,500 for dredging.

## Table C-180

### WATER QUALITY MANAGEMENT MEASURES FOR BARK LAKE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis, Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Economic Analysis, Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 80 |
| Livestock Waste Control | $ 13,600 | $ 1,200 | $ 10,100 | $ 13,600 | $ 23,700 | $ 600 | $ 900 | $ 1,500 | | |
| Rural Conservation Practices and Streambank Protection[b] | 307,100 | 40,000 | 258,600 | 202,100 | 460,700 | 16,400 | 12,800 | 29,200 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,200 | Minimal | 17,900 | 17,900 | Minimal | 1,100 | 1,100 | | |
| Total | 320,700 | 42,400 | 268,700 | 233,600 | 502,300 | 17,000 | 14,800 | 31,800 | | |
| Macrophyte Harvesting[c] | 6,100 | 800 | 4,500 | 13,300 | 17,800 | 300 | 800 | 1,100 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[d] | 4,400 | 100 | 3,300 | 1,700 | 5,000 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[e] | 6,500 | – | 4,800 | – | 4,800 | 300 | – | 300 | Accelerate lake improvement; prevent release of nutrient from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,h] | 130,000 | – | 97,100 | – | 97,100 | 6,200 | – | 6,200 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 220,200 | – | 164,500 | – | 164,500 | 10,400 | – | 10,400 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Bark Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Bark Lake drainage basin include a capital cost over the period of 1975-2000 of $1,035,000, an average annual operation and maintenance cost of $20,800, and a total 50-year present worth cost of $1,289,800.*

[b] *Rural land management practices necessary to achieve a 75 percent reduction in rural diffuse source pollutant loads.*

[c] *Cost estimated to harvest macrophytes from the 6.5 acres of Bark Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate the entire hypolimnion of the lake.*

[e] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 12.9 feet.*

[h] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate and amount of material to be filled or dredged.*

*Source: SEWRPC.*

Beaver Lake

Beaver Lake is a 316-acre lake located in the Town of Merton in Waukesha County. The lake is internally drained. Certain geomorphological characteristics of Beaver Lake are set forth in Table C-181, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-61 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-61 a major portion of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 239 privately owned onsite sewage disposal systems—111 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. The provision of sanitary sewer service is recommended for the lake watershed under planned year 2000 conditions.

As indicated in Table C-182, all direct sources combined contribute about 600 pounds of phosphorus annually to Beaver Lake. The major source of phosphorus in the lake watershed is septic tank systems. Also, as indicated in Table C-182, urban land uses in the watershed are expected to increase by about 44 percent under planned year 2000 conditions, with annual total phosphorus loadings to the lake expected to be increased to about 1,300 pounds as a result of increased construction activity. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.02 milligram per liter (mg/l) and 0.04 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Anticipated year 2000 pollutant loadings may be

### Table C-181

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF BEAVER LAKE

| Characteristic | Description |
|---|---|
| Surface Area . . . . . . . . . . . . | 316 acres |
| Direct Tributary Drainage Area . . . . . . . . . . . . . . . . | 1,119 acres |
| Shoreline . . . . . . . . . . . . . . | 3.60 miles |
| Depth | |
| Maximum . . . . . . . . . . . | 46 feet |
| Mean . . . . . . . . . . . . . . . | 16 feet |
| Volume . . . . . . . . . . . . . . . | 5,056 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] . . . . . | 839 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.51 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Table C-182

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO BEAVER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) . . . . . . . . . . . . . | 689 | 108 | 17.1 | 987 | 129 | 10.3 |
| Land under Development—Construction Activities (acres) . . . . . . . . . . . . . . . . . | – | – | – | 20 | 910 | 72.3 |
| Onsite Sewage Disposal Septic Tank Systems[b] . . . . . . . . . . . . . . . . . | 111 | 321 | 50.7 | 16 | 46 | 3.7 |
| Rural Land Cover (acres) . . . . . . . . . . . . . | 430 | 46 | 7.3 | 112 | 16 | 1.2 |
| Livestock Operations (animal units) . . . . . . | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) . . . . . . . . . . . . . | 316 | 158 | 24.9 | 316 | 158 | 12.5 |
| Total | – | 633 | 100.0 | – | 1,259 | 100.0 |

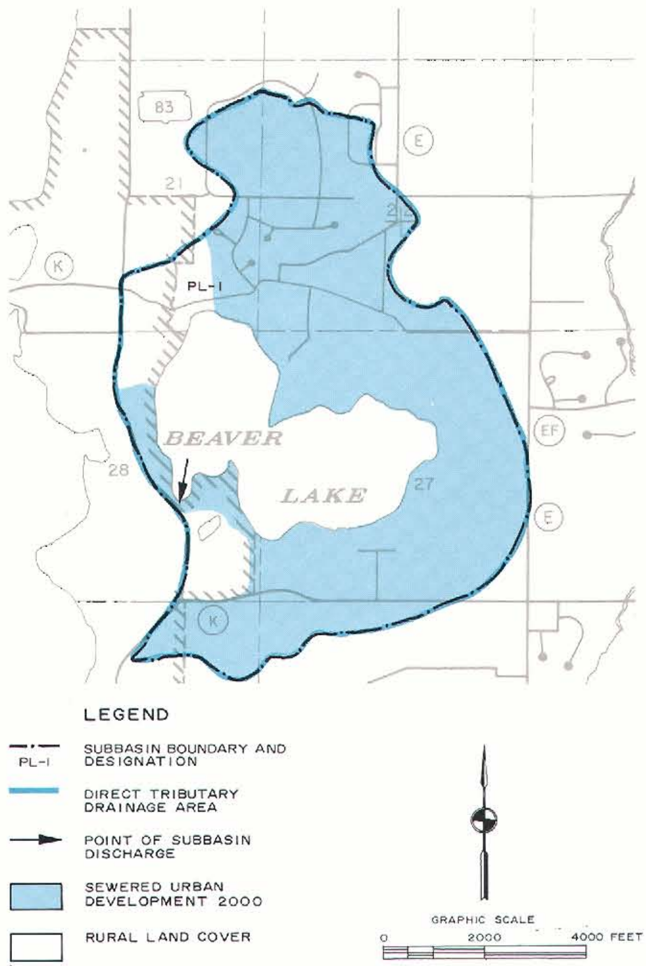
[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

### Map C-61

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF BEAVER LAKE: 2000




Beaver Lake has a direct tributary drainage area of about 1,119 acres. About 112 acres, or 10 percent of the drainage area, are planned to be in rural land cover, and 307 acres, or 88 percent, to be in urban land cover. Over the planning period an average of about 20 acres may be expected to be converted annually to urban land cover. It is estimated that a 50 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

expected to result in total phosphorus concentrations in Beaver Lake which exceed the recommended level for recreational use and for the maintenance of a warm-water fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-183, along with the associated costs and anticipated effectiveness. Measures to control construction activity contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank system

## Table C-183

### WATER QUALITY MANAGEMENT MEASURES FOR BEAVER LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: 1975-2025: Operation and Maintenance | Present Worth: 1975-2025: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: 1975-2025: Operation and Maintenance | Equivalent Annual: 1975-2025: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | |
| Minimum Rural Conservation Practices | $ 100 | $ 500 | $ 100 | $ 6,000 | $ 6,100 | Minimal | $ 400 | $ 400 | | |
| Construction Erosion Control Practices[d] | 933,200 | 8,100 | 700,500 | 127,400 | 827,900 | 44,400 | 8,100 | 52,500 | | 70 |
| Low Cost Urban Land Management Practices | Minimal | 1,400 | Minimal | 19,300 | 19,300 | Minimal | 1,200 | 1,200 | | |
| Total | 933,300 | 10,000 | 700,600 | 152,700 | 853,300 | 44,400 | 9,700 | 54,100 | | |
| Macrophyte Harvesting[e] | 20,500 | 2,900 | 15,300 | 45,700 | 61,000 | 1,000 | 2,900 | 2,900 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 30,000 | 800 | 22,400 | 11,800 | 34,200 | 1,400 | 800 | 2,200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 15,000 to 31,600 | – | 11,200 to 23,600 | – | 11,200 to 23,600 | 700 to 1,500 | – | 700 to 1,500 | Accelerate lake improvement; prevent release of nutrient from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 632,000 | – | 472,300 | – | 472,300 | 30,000 | – | 30,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Beaver Lake drainage basin include a capital cost over the period of 1975-2000 of $1,312,000, an average annual operation and maintenance cost of $9,800, and a total 50-year present worth cost of $890,200.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Beaver Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Beaver Lake drainage basin include a capital cost over the period of 1975-2000 of $72,000, an average annual operation and maintenance cost of $900, and a total 50-year present worth cost of $70,800.*

[d] *Cost estimated to control erosion from the estimated 20.2 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 22 acres of Beaver Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-183 may include nutrient inactivation, hypolimnetic aeration, and sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Beaver Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Beaver Lake would entail a total capital cost of about $933,300, and an average annual operation and maintenance cost of about $10,000. The total 50-year present worth cost of these source control measures is $853,300, with an equivalent annual cost of $54,100. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $15,000 for nutrient inactivation to $632,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $11,200 for nutrient inactivation to $472,300 for sediment covering.

Comus Lake

Comus Lake is a 117-acre lake located in the Town and City of Delavan in Walworth County. The lake is formed by a dam on Turtle Creek. Certain geomorphological characteristics of Comus Lake are set forth in Table C-184, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-62 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality plan. The delineated tributary drainage area should be refined in a more detailed local lake study. As shown on Map C-62, a major portion of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 39 privately owned onsite sewage disposal systems—four of which are located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-185, all direct sources combined contribute about 1,600 pounds of phosphorus annually to Comus Lake. An additional 1,300 pounds of phos-

Table C-184

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF COMUS LAKE

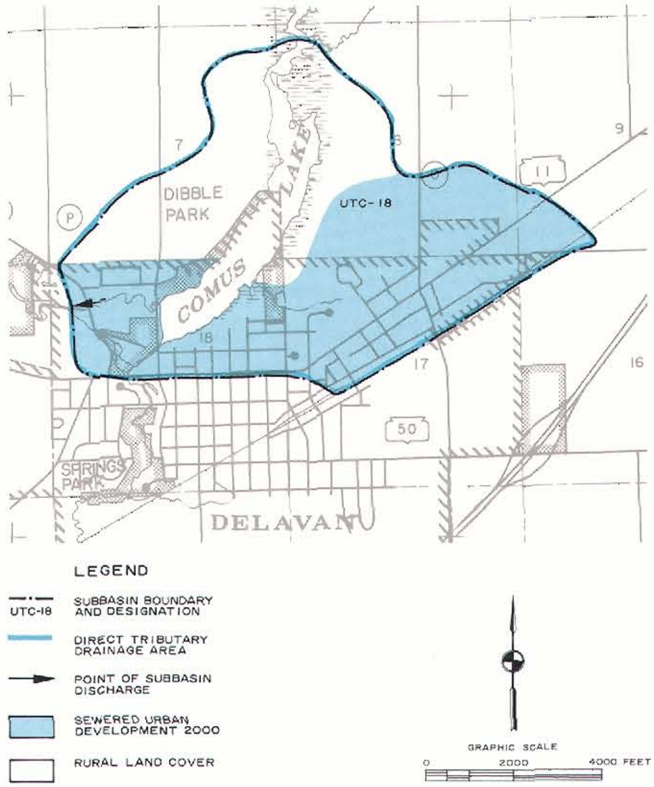
| Characteristic | Description |
|---|---|
| Surface Area | 117 acres |
| Direct Tributary Drainage Area | 1,107 acres |
| Shoreline | 5.10 miles |
| Depth | |
| Maximum | 6 feet |
| Mean | 5.2 feet |
| Volume | 608 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 2,329 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; some macrophyte growth; frequent fish winterkill |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.29 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-62

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF COMUS LAKE: 2000




Comus Lake has a direct tributary drainage area of about 1,107 acres. About 726 acres, or 66 percent of the drainage area, are planned to be in rural land cover, and 381 acres, or 34 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-185

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO COMUS LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 381 | 271 | 17.0 | 381 | 271 | 17.0 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | less than 5 | 12 | 0.7 | less than 5 | 6 | 0.4 |
| Rural Land Cover (acres) | 726 | 164 | 10.3 | 726 | 164 | 10.3 |
| Livestock Operations (animal units) | 165 | 1,089 | 68.3 | 165 | 1,089 | 68.6 |
| Atmospheric Contribution (acres of receiving surface water) | 117 | 58 | 3.7 | 117 | 58 | 3.7 |
| Total | – | 1,594[c] | 100.0 | – | 1,588[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 1,290 pounds per year, nor the anticipated year 2000 phosphorus load of 970 pounds per year contributed from the upstream inflow of Turtle Creek.*

*Source: SEWRPC.*

phorus enter the lake annually as inflow from Turtle Creek. The major direct source of phosphorus in the lake watershed is livestock operations. Also, as indicated in Table C-185, land uses in the watershed are not expected to change significantly under planned year 2000 land cover conditions, although phosphorus inflow from Turtle Creek is expected to be reduced to about 970 pounds per year as a result of diffuse source controls. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.04 milligram per liter (mg/l) and 0.03 mg/l, respectively. The Commission recommends a level of 0.02 or less mg/l of total phosphorus for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Comus Lake which exceeds the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-186, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service to the lake watershed, improved septic tank system management, minimum measures to reduce

### Table C-186

### WATER QUALITY MANAGEMENT MEASURES FOR COMUS LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentration | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 70 |
| Livestock Waste Control | $ 14,500 | $ 1,200 | $ 10,800 | $ 14,600 | $ 25,400 | $ 700 | $ 900 | $ 1,600 | | |
| Minimum Rural Conservation Practices | 200 | 1,300 | 100 | 15,800 | 15,900 | 0 | 1,000 | 1,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 600 | Minimal | 8,900 | 8,900 | Minimal | 600 | 600 | | |
| Total | 14,700 | 3,100 | 10,900 | 39,300 | 50,200 | 700 | 2,500 | 3,200 | | |
| Macrophyte Harvesting[d] | 46,600 | 6,500 | 34,800 | 102,400 | 137,200 | 2,200 | 6,500 | 8,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational potential | Minimal additional reduction |
| Aeration[e] | 4,000 | 100 | 3,000 | 1,600 | 4,600 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[f,h] | 234,000 | – | 174,900 | – | 174,900 | 11,100 | – | 11,100 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 1,849,500 | – | 1,382,100 | – | 1,382,100 | 87,700 | – | 87,700 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Comus Lake drainage basin include a capital cost over the period of 1975-2000 of $920,000, an average annual operation and maintenance cost of $27,000, and a total 50-year present worth cost of $940,700.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Comus Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Comus Lake drainage basin include a capital cost over the period of 1975-2000 of $9,000, an average annual operation and maintenance cost of $1,100, and a total 50-year present worth cost of $40,800.*

[d] *Cost estimated to harvest macrophytes from the 50 acres of Comus Lake subject to excessive macrophyte growth.*

[e] *Cost estimated to aerate 20 acres hypolimnion of the lake.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 5.2 feet.*

[h] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands. To achieve the reduction of total phosphorus loading to Comus Lake, it is also imperative that the nonpoint source control measures recommended for the Lower Rock River basin be implemented in that part of the Turtle Creek basin above Comus Lake.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the above point and diffuse source controls. Alternative restoration measures as set forth in Table C-186 may include aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Comus Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint pollution control measures to control the nutrient inputs to Comus Lake would entail a total capital cost of about $14,700, and an average annual operation and maintenance cost of about $3,100. The total 50-year present worth of these source control measures, is $50,200 with an equivalent annual cost of $3,200. If in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,000 for aeration to $1,849,500 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,600 for aeration to $1,382,100 for dredging.

## Cravath Lake

Cravath Lake is a 65-acre lake located in the City of Whitewater in Walworth County. The lake drains to Whitewater Creek. Certain geomorphological characteristics of Cravath Lake are set forth in Table C-187, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-63 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-63, a large portion of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 20 privately owned onsite sewage disposal systems—two located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-188, all direct sources combined contribute about 200 pounds of phosphorus annually to Cravath Lake. An additional 600 pounds of phosphorus

Table C-187

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF CRAVATH LAKE

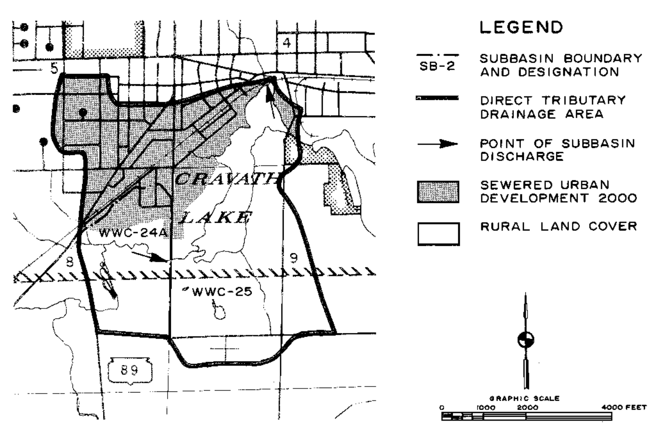
| Characteristic | Description |
|---|---|
| Surface Area | 65 acres |
| Direct Tributary Drainage Area | 546 acres |
| Shoreline | 2.5 miles |
| Depth | |
| Maximum | 10 feet |
| Mean | 2.7 feet |
| Volume | 176 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,152 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; potential for winter fishkills |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-63

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF CRAVATH LAKE: 2000




Cravath Lake has a direct tributary drainage area of about 546 acres. About 302 acres, or 55 percent of the drainage area, are planned to be in rural land cover, and 244 acres, or 45 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 25 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-188

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO CRAVATH LAKE: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 244 | 123 | 64.4 | 244 | 123 | 65.4 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | less than 5 | 6 | 3.1 | less than 5 | 3 | 1.6 |
| Rural Land Cover (acres) | 302 | 30 | 15.7 | 302 | 30 | 16.0 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 65 | 32 | 16.8 | 65 | 32 | 17.0 |
| Total | – | 191[c] | 100.0 | – | 188[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated and year 2000 anticipated phosphorus loads of 600 pounds per year and 400 pounds per year, respectively, contributed by the upstream drainage from Whitewater Creek and a major unnamed tributary to the south of the lake.*

*Source: SEWRPC.*

enters the lake annually from the unnamed tributary to the south of the lake and from Tripp Lake. It is assumed, however, that most of the phorphorus load from Tripp Lake flushes through Cravath Lake without significant deposition or biological uptake. Also, as indicated in Table C-188, land uses are not expected to change significantly under planned year 2000 land cover conditions. The total phosphorus load will be reduced somewhat as a result of nonpoint source management practices recommended for the upstream drainage area, thus reducing that contribution to 400 pounds annually. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.03 milligram per liter (mg/l) and 0.024 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Cravath Lake which slightly exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-189, along with the associated costs and anticipated effectiveness. The recommended minimum controls include the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands. Implementation of similar measures as recommended in the nonpoint source plan element for the upstream tributary area is necessary to reduce Cravath Lake phosphorus loadings to the recommended levels.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-189 may include total aeration, nutrient inactivation, sediment covering, or dredging. A fifth alternative, drawing down the lake and allowing the sediments to dry and consolidate, would have little monetary cost but could entail significant environmental and short-term aesthetic effects. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Cravath Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures in the direct tributary watershed to control the nutrient inputs to Cravath Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $900. The total 50-year present worth cost of these source control measures is $12,500, with an equivalent annual cost of $800. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $6,000 for aeration to $1,289,600 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,800 for nutrient inactivation to $964,300 for dredging.

Crooked Lake

Crooked Lake is a 58-acre lake located in the Town of Summit in Waukesha County. The lake drains to the Bark River. Certain geomorphological characteristics of Crooked Lake are set forth in Table C-190, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-64 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-64, major urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 39 privately owned onsite sewage disposal systems—six of which are located in areas covered by soils having severe limitations for the use of such systems—were in operation in the lake watershed area.

## Table C-189

### WATER QUALITY MANAGEMENT MEASURES FOR CRAVATH LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentration | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ 100 | $ 500 | $ 100 | $ 6,400 | $ 6,500 | Minimal | $ 400 | $ 400 | | |
| Low Cost Urban Land Management Practices | Minimal | 400 | Minimal | 6,000 | 6,000 | Minimal | 400 | 400 | | |
| Total | 100 | 900 | 100 | 12,400 | 12,500 | Minimal | 800 | 800 | | 25[k] |
| Macrophyte Harvesting[d] | 28,000 | 3,900 | 20,900 | 61,500 | 82,400 | 1,300 | 3,900 | 5,200 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Total Aeration[e] | 6,000 | 200 | 4,500 | 2,400 | 6,900 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 6,500 | – | 4,800 | – | 4,800 | 300 | – | 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Lake Draw Down | Minimal | | Minimal | | | Minimal | | | Consolidation of sediments | No additional reduction |
| Sediment Covering[g,h,i] | 130,000 | – | 97,100 | – | 97,100 | 6,200 | – | 6,200 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[h,i,j] | 1,289,600 | – | 964,300 | – | 964,300 | 61,100 | – | 61,100 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Cravath Lake drainage basin include a capital cost over the period of 1975-2000 of $80,000, an average annual operation and maintenance cost of $11,000, and a total 50-year present worth cost of $218,900.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Cravath Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Cravath Lake drainage basin include a capital cost over the period of 1975-2000 of $45,000, an average annual operation and maintenance cost of $500, and a total 50-year present worth cost of $18,900.*

[d] *Cost estimated to harvest macrophytes from the 30 acres of Cravath Lake subject to excessive macrophyte growth.*

[e] *Cost to aerate 30 acres of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *These costs may be significantly reduced if the dam is opened and the lake is drawn down. This action, however, entails nonmonetary costs associated with a dry lakebed.*

[i] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

[j] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 2.7 feet.*

[k] *The reduction in the direct phosphorus load to Cravath Lake must be augmented by the implementation of minimum practices in the upstream drainage area of Whitewater Creek and the major tributary to the south of the lake, if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Cravath Lake is to meet the water quality criteria for recreation and a warmwater fishery.*

*Source: SEWRPC.*

As indicated in Table C-191, direct tributary sources contribute about 150 pounds of phosphorus annually to Crooked Lake. An additional 12,000 pounds of phosphorus enter the lake annually as inflow from Lower Nemahbin Lake via the Bark River. Therefore, the major source of phosphorus in the lake watershed is inflow from the Bark River. Also, as indicated in Table C-191, land uses in the watershed are not expected to change significantly under planned year 2000 land cover conditions. Direct phosphorus loads will be reduced to about 140 pounds annually as a result of sanitary sewer service. The inflow from Lower Nemahbin Lake, however, is expected to be reduced to about 4,300 pounds per year as a result of improved management of the upstream drainage area. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.16 milligram per liter (mg/l) and 0.06 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the maintenance of a warmwater fishery and recreational use classification. Existing and

Table C-190

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF CROOKED LAKE

| Characteristic | Description |
|---|---|
| Surface Area . . . . . . . . . . . . | 58 acres |
| Direct Tributary Drainage Area . . . . . . . . . . . . . . . | 794 acres |
| Shoreline . . . . . . . . . . . . . . | 2.30 miles |
| Depth | |
| Maximum . . . . . . . . . . . | 16 feet |
| Mean . . . . . . . . . . . . . . . | 7 feet |
| Volume . . . . . . . . . . . . . . . | 406 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] . . . . . | 125 persons |
| General Existing Water Quality Conditions: | Generally good except for excessive macrophyte growth in the littoral zone |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

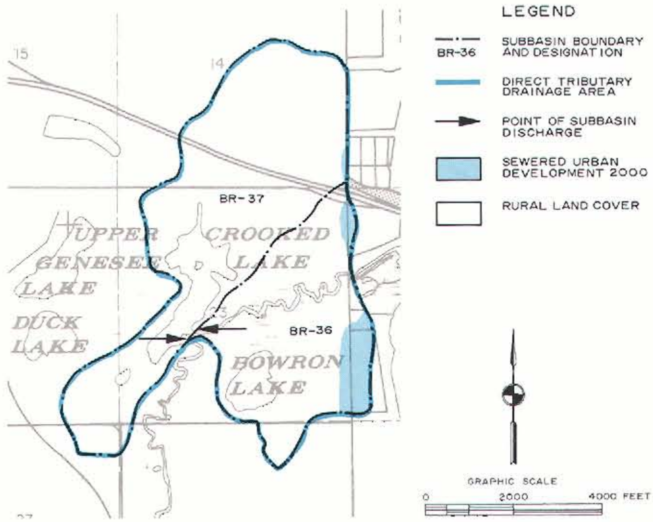
*Source: SEWRPC.*

anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Crooked Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery. Because of the excessive total phosphorus loadings from the upstream tributary area of the Bark River, Crooked Lake cannot be expected to achieve the 0.02 mg/l total phosphorus level recommended to support the full recreational use and warmwater fishery classification. Therefore, the Commission has recommended that Crooked Lake be classified for limited recreational use and a warmwater fishery, for which expensive nonpoint source control measures are probably not warranted.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-192, along with the associated costs and anticipated effectiveness. Measures to control the phosphorus contribution include: the provision of sanitary sewer service, septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices; and low-cost measures to reduce pollutant runoff from urban lands.

Map C-64

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF CROOKED LAKE: 2000




Crooked Lake has a direct tributary drainage area of about 794 acres. About 698 acres, or 88 percent of the drainage area, are planned to be in rural land cover, and 96 acres, or 12 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. A combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program, should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-191

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO CROOKED LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) . . . . . . . . . . . . . | 96 | 28 | 19.2 | 96 | 28 | 20.1 |
| Land under Development—Construction Activities (acres) . . . . . . . . . . . . . . . . . | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] . . . . . . . . . . . . . . . . . . | 6 | 17 | 12.0 | 4 | 12 | 8.6 |
| Rural Land Cover (acres) . . . . . . . . . . . . . | 698 | 70 | 48.8 | 698 | 70 | 50.4 |
| Livestock Operations (animal units) . . . . . . . | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) . . . . . . . . . . . . . | 58 | 29 | 20.0 | 58 | 29 | 20.9 |
| Total | – | 144[c] | 100.0 | – | 139[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 11,960 pounds per year or the year 2000 anticipated phosphorus load of 4,300 pounds per year contributed by the drainage from the upstream portion of the Bark River through the Lower Nemahbin Lake Outlet.*

*Source: SEWRPC.*

## Table C-192

### WATER QUALITY MANAGEMENT MEASURES FOR CROOKED LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total *Capital* | Average Annual Operation and *Maintenance* | *Capital* | Operation and *Maintenance* | *Total* | *Capital* | Operation and *Maintenance* | *Total* | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Slightly reduced nutrient concentrations, maintenance of the existing water quality conditions, and public health protection | |
| Minimum Rural Conservation Practices | $ 100 | $ 1,200 | $ 100 | $ 14,900 | $ 15,000 | $ 100 | $ 900 | $ 1,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 200 | Minimal | 2,300 | 2,300 | Minimal | 100 | 100 | | |
| Total Diffuse Source Control | 100 | 1,400 | 100 | 17,200 | 17,300 | 100 | 1,000 | 1,100 | | Minimal |
| Macrophyte Harvesting[d] | 18,600 | 2,600 | 13,900 | 41,000 | 54,900 | 900 | 2,600 | 3,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Nutrient Inactivation[e] | 5,800 | – | 4,300 | – | 4,300 | 300 | – | 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,h] | 116,000 | – | 86,700 | – | 86,700 | 5,500 | – | 5,500 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[g,h] | 748,400 | – | 559,300 | – | 559,300 | 35,500 | – | 35,500 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Crooked Lake drainage basin include a capital cost over the period of 1975-2000 of $112,000, an average annual operation and maintenance cost of $800, and a total 50-year present worth cost of $76,000.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Crooked Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Crooked Lake drainage basin include a capital cost over the period of 1975-2000 of $27,000, an average annual operation and maintenance cost of $700, and a total 50-year present worth cost of $41,500.*

[d] *Cost estimated to harvest macrophytes from the 20 acres of Crooked Lake subject to excessive macrophyte growth.*

[e] *The lower cost for nutrient inactivation is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 7 feet.*

[h] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-192 may include nutrient inactivation, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Crooked Lake requires that the recommended water quality management measures be implemented.

The application of the above-listed minimum nonpoint source pollution control measures to control the nutrient inputs to Crooked Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $1,400. The total 50-year present worth cost of these source control measures is $17,300, with an equivalent annual cost of $1,100. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $5,800 for nutrient inactivation to $748,400 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,300 for nutrient inactivation to $559,300 for dredging.

Delavan Lake

Delavan Lake is a 2,072-acre lake located in the Town of Delavan in Walworth County. The lake drains to Turtle Creek via Jackson Creek. Certain geomorphological characteristics of Delavan Lake are set forth in Table C-193, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[16] Map C-65 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-65, a portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 1,800 privately owned onsite sewage disposal systems—368 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. The area served by sanitary sewer service is proposed to be significantly extended under planned year 2000 conditions.

As indicated in Table C-194, all direct sources combined contribute about 17,400 pounds of phosphorus annually to Delavan Lake. In addition, 17,500 pounds of phosphorus annually enter the lake from Jackson Creek. The major direct source of phosphorus in the lake watershed is livestock waste contributions. Also, as indicated in Table C-194, urban land uses in the watershed are expected to increase by about 10 percent under planned year 2000 land cover conditions, with annual total direct phosphorus loadings to the lake expected to be reduced to about 12,000 pounds as a result of the extension of sanitary sewers. The load from Jackson Creek is expected to be reduced to about 1,700 pounds annually as a result of the phasing out of two sewage treatment plants currently discharging to the stream. The estimated total phosphorus concentrations during spirng overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.17 milligram per liter (mg/l) and 0.07 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus concentrations for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Delavan Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-195, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank system management, measures to reduce pollutant runoff from rural lands by

Table C-193

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF DELAVAN LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 2,072 acres |
| Direct Tributary Drainage Area | 12,357 acres |
| Shoreline | 10.1 miles |
| Depth | |
| Maximum | 56 feet |
| Mean | 25 feet |
| Volume | 51,800 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 7,342 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; occasional fish winterkill; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.29 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

C-194

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO DELAVAN LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,675 | 804 | 4.6 | 1,855 | 890 | 7.5 |
| Land under Development—Construction Activities (acres) | 7 | 315 | 1.8 | 7 | 315 | 2.6 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 368 | 1,065 | 6.1 | 27 | 78 | 0.7 |
| Rural Land Cover (acres) | 10,675 | 2,334 | 13.4 | 10,495 | 1,749 | 14.7 |
| Livestock Operations (animal units) | 1,192 | 7,867 | 45.1 | 1,192 | 7,867 | 65.8 |
| Atmospheric Contribution (acres of receiving surface water) | 2,072 | 1,036 | 5.9 | 2,072 | 1,036 | 8.7 |
| Point Sources (ngd) | 0.2 | 4,012 | 23.1 | – | – | – |
| Total | – | 17,433[c] | 100.0 | – | 11,935[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

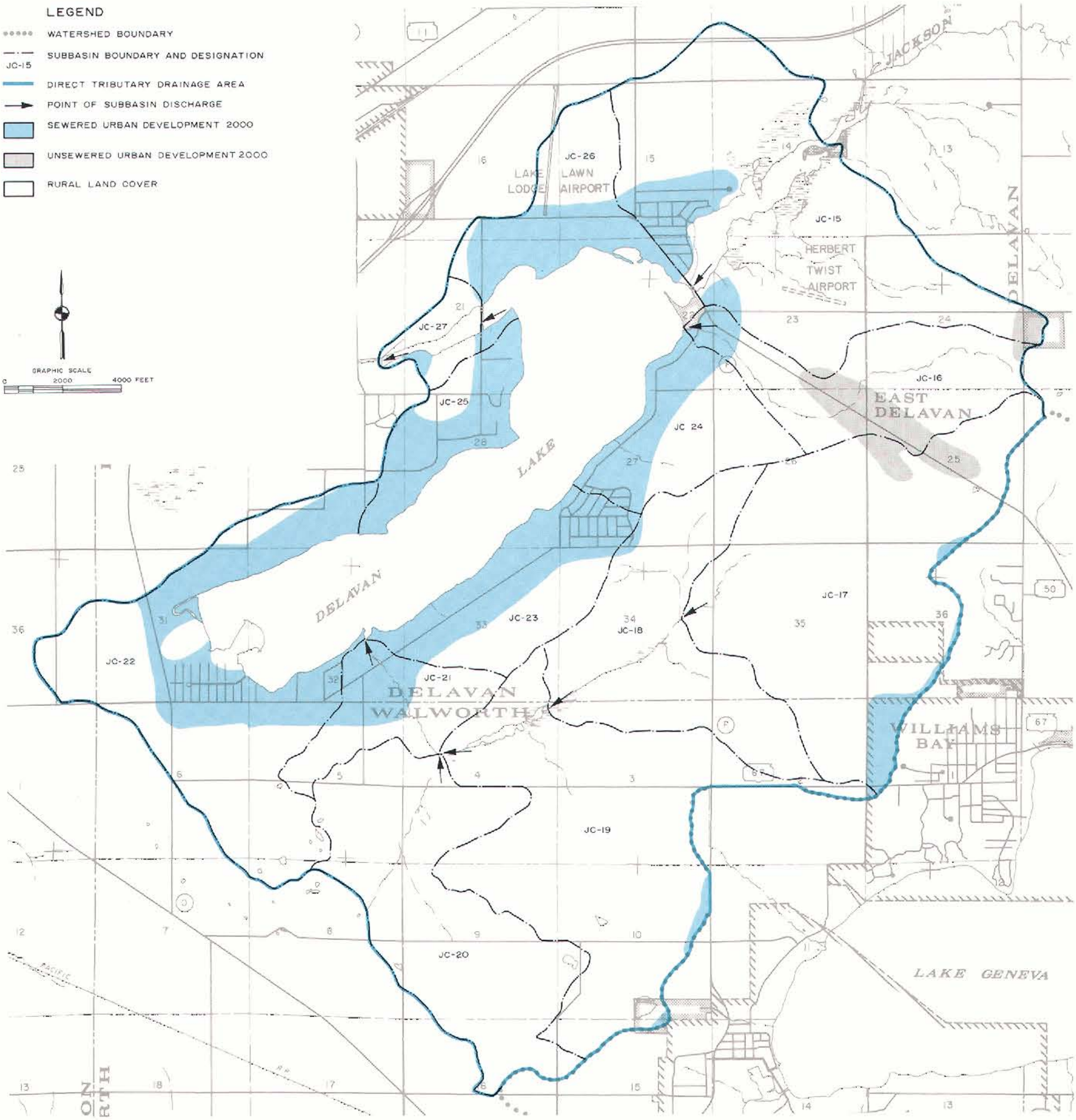
[c] *Does not include the 1975 estimated phosphorus load of 17,480 pounds per year nor the year 2000 anticipated phosphorus load of 1,700 pounds per year contributed by the drainage from the Jackson Creek outlet.*

*Source: SEWRPC.*

[16] *Report on Delavan Lake, National Eutrophication Survey, U.S. Environmental Protection Agency, 1974.*

Map C-65

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF DELAVAN LAKE: 2000




Delavan Lake has a direct tributary drainage area of about 12,357 acres. About 10,495 acres, or 85 percent of the drainage area, are planned to be in rural land cover, and 1,862 acres, or 15 percent, to be in urban land cover. Over the planning period an average of about seven acres may be expected to be converted annually to urban land cover. It is estimated that a 70 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-195 may include nutrient inactivation, sediment covering, and hypolimnetic aeration. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Delavan Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Delavan Lake would entail a total capital cost of about $1,192,800, and an average annual operation

**Table C-195**

**WATER QUALITY MANAGEMENT MEASURES FOR DELAVAN LAKE IN WALWORTH COUNTY**

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | -- | -- | -- | -- | -- | -- | -- | -- | Protect public health and drinking water supplies; reduce nutrient concentrations | -- |
| Septic Tank System Management[c] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 104,900 | $ 8,900 | $ 78,400 | $ 105,300 | $ 183,700 | $ 5,000 | $ 6,700 | $ 11,700 | | |
| Minimum Rural Construction Practices | 2,200 | 18,800 | 1,600 | 229,900 | 231,500 | 100 | 14,600 | 14,700 | | |
| Construction Erosion Control Practices[d] | 1,085,700 | 9,400 | 814,900 | 148,200 | 963,100 | 51,700 | 9,400 | 61,100 | | 80 |
| Low Cost Urban Land Management Practices | Minimal | 2,800 | Minimal | 41,900 | 41,900 | Minimal | 2,700 | 2,700 | | |
| Total | 1,192,800 | 39,900 | 894,900 | 525,300 | 1,420,200 | 56,800 | 33,400 | 90,200 | | |
| Macrophyte Harvesting[e] | 18,600 | 2,600 | 13,900 | 41,000 | 54,900 | 900 | 2,600 | 3,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 332,000 | 8,300 | 248,100 | 130,800 | 378,900 | 15,700 | 8,300 | 24,000 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 207,200 | -- | 154,800 | -- | 154,800 | 9,800 | -- | 9,800 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 4,144,000 | -- | 3,096,800 | -- | 3,096,800 | 196,500 | -- | 196,500 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Delavan Lake drainage basin include a capital cost over the period of 1975-2000 of $3,572,000, an average annual operation and maintenance cost of $40,500, and a total 50-year present worth cost of $2,639,800.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Delavan Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Delavan Lake drainage basin include a capital cost over the period of 1975-2000 of $121,500, an average annual operation and maintenance cost of $20,100, and a total 50-year present worth cost of $739,100.*

[d] *Cost estimated to control erosion from the estimated 23.5 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 20 acres of Delavan Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *The costs for sediment covering may vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

and maintenance cost of about $39,900. The total 50-year present worth cost of these source control measures is $1,420,200, with an equivalent annual cost of $90,200. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $207,200 for nutrient inactivation to $4,144,400 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $154,800 for nutrient inactivation to $3,096,800 for sediment covering.

Druid Lake

Druid Lake is a 124-acre lake located in the Town of Erin in Washington County. The lake drains to the Ashippun River. Certain geomorphological characteristics of Druid Lake are set forth in Table C-196, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-66 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-66, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 88 privately owned onsite sewage disposal systems—36 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-197, all direct sources combined contribute about 260 pounds of phosphorus annually to Druid Lake. The major direct source of phosphorus in

Table C-196

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF DRUID LAKE

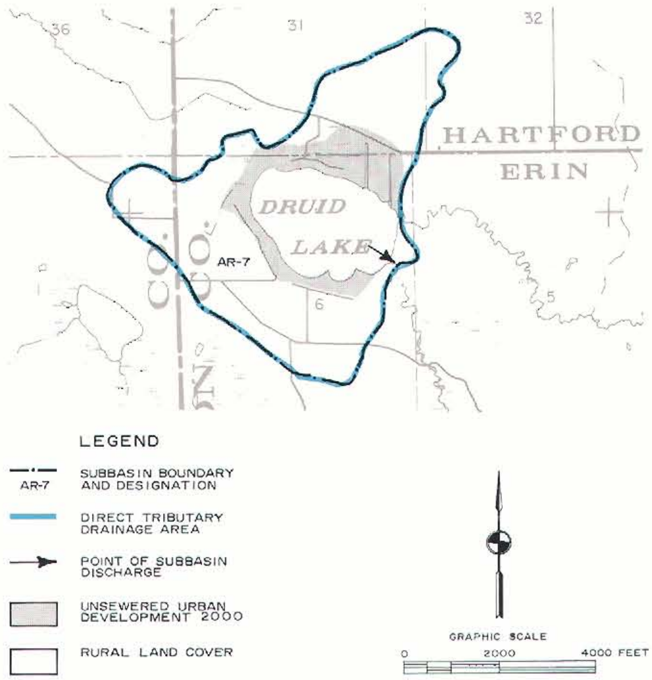
| Characteristic | Description |
|---|---|
| Surface Area | 124 acres |
| Direct Tributary Drainage Area | 481 acres |
| Shoreline | 2.5 miles |
| Depth | |
| Maximum | 45 feet |
| Mean | 15 feet |
| Volume | 3,150 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 348 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; high nutrient concentrations; low dissolved oxygen concentration in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.96 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-66

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF DRUID LAKE: 2000




Druid Lake has a direct tributary drainage area of about 481 acres. About 424 acres, or 88 percent of the drainage area, are planned to be in rural land cover, and 57 acres, or 12 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-197

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO DRUID LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 57 | 15 | 5.8 | 57 | 15 | 5.8 |
| Land under Development—Construction Activities (acres) | — | — | — | — | — | — |
| Onsite Sewage Disposal Septic Tank Systems[b] | 36 | 104 | 39.8 | 36 | 104 | 39.8 |
| Rural Land Cover (acres) | 424 | 40 | 15.3 | 424 | 40 | 15.3 |
| Livestock Operations (animal units) | 6 | 40 | 15.3 | 6 | 40 | 15.3 |
| Atmospheric Contribution (acres of receiving surface water) | 124 | 62 | 23.8 | 124 | 62 | 23.8 |
| Total | — | 261[c] | 100.0 | — | 261[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated and year 2000 anticipated phosphorus load of 500 pounds per year and 400 pounds per year, respectively, contributed by the drainage from the upstream portions of the Ashippun River.*

*Source: SEWRPC.*

the lake watershed is septic tank systems. An additional 500 pounds of phosphorus enter the lake annually from Ashippun River inflow. As indicated in Table C-197, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.03 milligram per liter (mg/l). The Commission recommends a level of 0.02 or less mg/l of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Druid Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-198, along with the associated costs and anticipated effectiveness. Measures to control septic tank system contributions appear to be the most effecitve way to substantially reduce phosphorus loadings to the lake. Other needed measures include: livestock waste runoff control, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands. In addition, these same measures must be implemented in the upstream Ashippun River watershed as recommended in the nonpoint source plan element if the total lake load of phosphorus is to be reduced to desired levels.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte

**Table C-198**

**WATER QUALITY MANAGEMENT MEASURES FOR DRUID LAKE IN WASHINGTON COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
| Septic Tank System Management[b] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 60 |
| Livestock Waste Control | $ 500 | $ <100 | $ 400 | $ 500 | $ 900 | $ <100 | $ <100 | $ 200 | | |
| Minimum Rural Conservation Practices | 100 | 700 | 100 | 9,100 | 9,200 | <100 | 600 | 700 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 1,400 | 1,400 | Minimal | 100 | 100 | | |
| Total | 600 | 900 | 500 | 11,000 | 11,500 | 200 | 800 | 1,000 | | |
| Macrophyte Harvesting[c] | 7,000 | 1,000 | 5,200 | 15,800 | 21,000 | 300 | 1,000 | 1,300 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[d] | 17,400 | 400 | 13,100 | 6,300 | 19,400 | 800 | 400 | 1,200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[e] | 8,700 to 12,400 | – | 6,500 to 9,300 | – | 6,500 to 9,300 | 400 to 600 | – | 400 to 600 | Accelerate lake improvement; prevent release of nutrient from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,g] | 248,000 | – | 185,300 | – | 185,300 | 11,800 | – | 11,800 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The reduction in direct phosphorus load to Druid Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Ashippun River if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Druid Lake is to meet the water quality criteria for recreation and a warmwater fishery.*

[b] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Druid Lake. However, because septic tank system management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Druid Lake drainage basin include a capital cost over the period 1975-2000 of $162,000, an average annual operation and maintenance cost of $3,000, and a total 50-year present worth cost of $193,100.*

[c] *Cost estimated to harvest macrophytes from the 7.5 acres of Druid Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate the entire hypolimnion of the lake.*

[e] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *The costs of sediment covering may vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC*

growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the afore listed nonpoint source controls. Alternative restoration measures as set forth in Table C-198 may include hypolimnetic aeration, nutrient inactivation, and sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Druid Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Druid Lake would entail a total capital cost of about $600, and an average annual operation and maintenance cost of about $900. The total 50-year present worth cost of these source control measures is $11,500, with an equivalent annual cost of $1,000. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $8,700 for nutrient inactivation to $248,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $6,500 for nutrient inactivation to $185,300 for sediment covering.

Lake Five

Lake Five is a 102-acre lake located in the Town of Richfield in Washington County. The lake is internally drained. Certain geomorphological characteristics of Lake Five are set forth in Table C-199, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-67 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-67, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 59 privately owned onsite sewage disposal systems—24 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed.

As indicated in Table C-200, all direct sources combined contribute about 200 pounds of phosphorus annually to Lake Five. The major source of phosphorus in the lake watershed is rural land runoff. Also, as indicated in Table C-200, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Five which do not exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. It is recommended that basic low-cost nonpoint source pollution control measures be implemented to ensure

Table C-199

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE FIVE

| Characteristic | Description |
|---|---|
| Surface Area | 102 acres |
| Direct Tributary Drainage Area | 823 acres |
| Shoreline | 1.90 miles |
| Depth | |
| Maximum | 22 feet |
| Mean | 10.9 feet |
| Volume | 1,112 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 234 persons |
| General Existing Water Quality Conditions: | Nuisance macrophyte growth; frequent fish winterkill |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.96 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-200

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE FIVE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 84 | 15 | 7.0 | 84 | 15 | 7.0 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 24 | 69 | 33.0 | 24 | 69 | 33.0 |
| Rural Land Cover (acres) | 739 | 75 | 35.8 | 739 | 75 | 35.8 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of Receiving surface water) | 102 | 51 | 24.2 | 102 | 51 | 24.2 |
| Total | – | 210 | 100.0 | – | 210 | 100.0 |

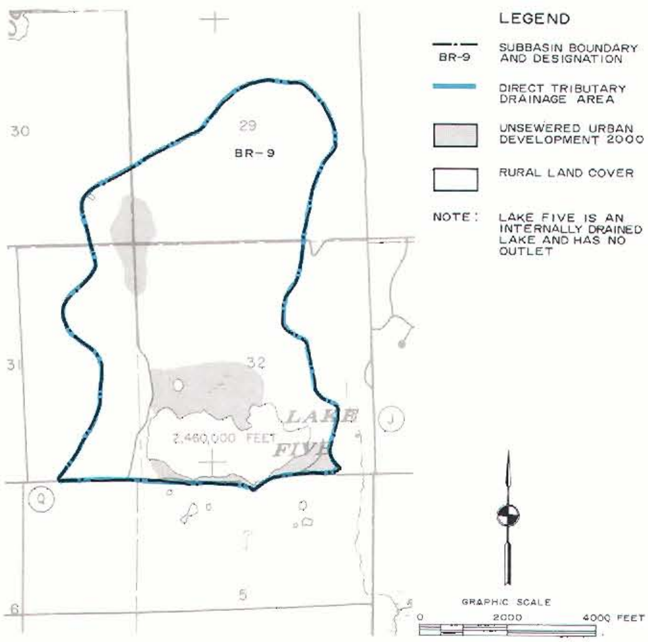
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-67

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE FIVE: 2000**




Lake Five has a direct tributary drainage area of about 823 acres. About 739 acres, or 90 percent of the drainage area, are planned to be in rural land cover, and 84 acres, or 10 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

continued high water quality in Lake Five. These measures are set forth in Table C-201, along with the associated costs and anticipated effectiveness. Measures to control septic tank system contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake while protecting public health. Other needed measures include: minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-201 may include aeration, nutrient inactivation, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lake Five requires that the recommended level of nutrient input be maintained.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lake Five would entail a total capital cost of about $200, and an average annual operation and maintenance cost of about $1,400. The total 50-year present worth cost of these source control measures is $17,900, with an equivalent annual cost of $1,100. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $2,000 for aeration to $674,600 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $1,800 for aeration to $504,100 for dredging.

Fowler Lake

Fowler Lake is a 78-acre lake located in the City of Oconomowoc in Waukesha County. The lake drains to Lac La Belle. Certain geomorphological characteristics of Fowler Lake are set forth in Table C-202, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-68 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-68, most of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 174 privately owned onsite sewage disposal systems—three of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-203, all direct sources combined contribute about 1,200 pounds of phosphorus annually to Fowler Lake. An additional 3,900 pounds of phosphorus enters the lake annually from the Oconomowoc River. The major direct source of phosphorus in the lake watershed is construction site runoff. Also, as indicated in Table C-203, urban land uses in the watershed are expected to increase about 45 percent under planned year 2000 land cover conditions, with annual total direct phosphorus loadings to the lake expected to increase to about 1,400 pounds. The phosphorus load from the Oconomowoc River is expected to decrease to about 1,000 pounds as a result of upstream water quality management actions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin charac-

## Table C-201

## WATER QUALITY MANAGEMENT MEASURES FOR LAKE FIVE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ 200 | $ 1,300 | $ 100 | $ 15,800 | $ 15,900 | Minimal | $ 1,000 | $ 1,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 2,000 | 2,000 | Minimal | 100 | 100 | | |
| Total | 200 | 1,400 | 100 | 17,800 | 17,900 | Minimal | 1,100 | 1,100 | | 45 |
| Macrophyte Harvesting[b] | 9,300 | 1,300 | 6,900 | 20,500 | 27,400 | 400 | 1,300 | 1,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[c] | 2,000 | <100 | 1,500 | 300 | 1,800 | 100 | – | 100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 10,200 | – | 7,600 | – | 7,600 | 500 | – | 500 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 204,000 | – | 152,400 | – | 152,400 | 9,700 | – | 9,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 674,600 | – | 504,100 | – | 504,100 | 32,000 | – | 32,000 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Five. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Five drainage basin include a capital cost over the period of 1975-2000 of $108,000, an average annual operation and maintenance cost of $2,100, and a total 50-year present worth cost of $129,100.*

[b] *Cost estimated to harvest macrophytes from the 10 acres of Lake Five subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate 10 acres of the hypolimnion.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs for sediment covering or dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material required to be filled or dredged.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 10.9 feet.*

*Source: SEWRPC.*

## Table C-202

## GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF FOWLER LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 78 acres |
| Direct Tributary Drainage Area | 1,478 acres |
| Shoreline | 1.70 miles |
| Depth: Maximum | 50 feet |
| Depth: Mean | 12.9 feet |
| Volume | 1,006 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 2,530 persons |
| General Existing Water Quality Conditions: | Generally good, except for nuisance macrophyte growth in shallow areas |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-203

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO FOWLER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975: Number | Existing 1975: Total Loading (pounds per year) | Existing 1975: Percent Distribution | Anticipated 2000[a]: Number | Anticipated 2000[a]: Total Loading (pounds per year) | Anticipated 2000[a]: Percent Distribution |
|---|---|---|---|---|---|---|
| Urban Land Cover (acres) | 777 | 271 | 23.0 | 1,126 | 523 | 37.4 |
| Land under Development—Construction Activities (acres) | 18 | 792 | 67.2 | 18 | 792 | 56.7 |
| Onsite Sewage Disposal Septic Tank Systems[b] | < 5 | 9 | 0.8 | < 5 | 9 | 0.6 |
| Rural Land Cover (acres) | 683 | 67 | 5.7 | 334 | 35 | 2.5 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contributions (acres of receiving surface water) | 78 | 39 | 3.3 | 78 | 39 | 2.8 |
| Total | – | 1,178[c] | 100.0 | – | 1,398[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

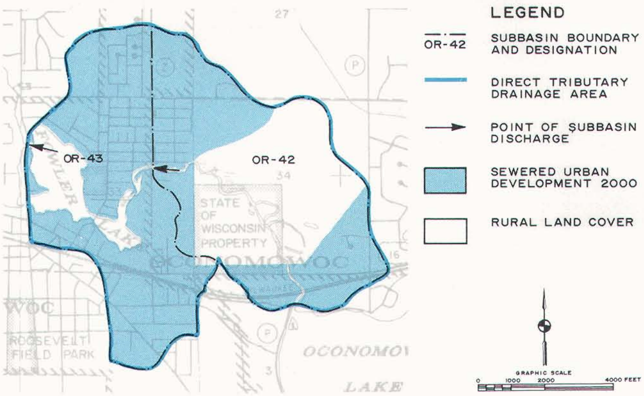
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphours load of 3,900 pounds per year or the year 2000 anticipated phosphorus load of 1,000 pounds per year contributed by the upstream drainage of the Oconomowoc River.*

*Source: SEWRPC.*

Map C-68

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF FOWLER LAKE: 2000




Fowler Lake has a direct tributary drainage area of about 1,478 acres. About 334 acres, or 23 percent of the drainage area, are planned to be in rural land cover, and 1,144 acres, or 77 percent, to be in urban land cover. Over the planning period an average of about 18 acres may be expected to be converted annually to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

teristics, are 0.05 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Fowler Lake which meet the recommended level for recreational use and for the maintenance of a warm-water fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-204, along with the associated costs and anticipated effectiveness. Measures to control construction site runoff contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-204 may include nutrient inactivation, hypolimnetic aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Fowler Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Fowler Lake would entail a total capital cost of about $813,200, and an average annual operation and maintenance cost of about $9,500. The total 50-year present worth cost of these source control measures is $755,600 with an equivalent annual cost of $48,000. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,000 for hypolimnetic aeration to $264,200 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,600 for hypolimnetic aeration to $197,400 for dredging.

Friess Lake

Friess Lake is a 119-acre lake located in the Town of Richfield in Washington County. The lake is one of the six major lakes in the Oconomowoc River chain of lakes. Certain geomorphological characteristics of Friess Lake are set forth in Table C-205, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[17] Map C-69 presents a graphic summary of the

[17] *See separately published SEWRPC Community Assistance Planning Report on Water Quality Management of Friess Lake, Washington County, for a more detailed discussion of the findings and recommendations of the detailed field study.*

## Table C-204

## WATER QUALITY MANAGEMENT MEASURES FOR FOWLER LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentration | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 60[k] |
| Minimum Rural Conservation Practices | $ 100 | $ 900 | $ 100 | $ 11,200 | $ 11,300 | $ < 100 | $ 700 | $ 800 | | |
| Construction Erosion Control Practices[d] | 813,000 | 7,000 | 610,300 | 111,000 | 721,300 | 38,700 | 7,000 | 45,700 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,600 | Minimal | 23,000 | 23,000 | Minimal | 1,500 | 1,500 | | |
| Total | 813,200 | 9,500 | 610,400 | 145,200 | 755,600 | 38,800 | 9,200 | 48,000 | | |
| Macrophyte Harvesting[e] | 10,300 | 1,400 | 7,700 | 22,100 | 29,800 | 500 | 1,400 | 1,900 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 4,000 | 100 | 3,000 | 1,600 | 4,600 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 7,800 | – | 5,800 | – | 5,800 | 400 | – | 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,j] | 156,000 | – | 116,600 | – | 116,600 | 7,400 | – | 7,400 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[i,j] | 264,200 | – | 197,400 | – | 197,400 | 12,500 | – | 12,500 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Fowler Lake drainage basin include a capital cost over the period of 1975-2000 of $2,716,000, an average annual operation and maintenance cost of $38,900, and a total 50-year present worth cost of $2,134,600.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Fowler Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Fowler Lake drainage basin include a capital cost over the period of 1975-2000 of $4,500, an average annual operation and maintenance cost of $200, and a total 50-year present worth cost of $9,900.*

[d] *Cost estimated to control erosion from the estimated 17.6 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 11 acres of Fowler Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 12.9 feet.*

[j] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

[k] *The reduction in the direct phosphorus load to Fowler Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Oconomowoc River if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Fowler Lake is to meet the water quality criteria for recreation and warmwater fishery.*

*Source: SEWRPC.*

proposed year 2000 land cover in the direct tributary lake watershed. As shown on Map C-69, none of the urban land in the direct tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 168 privately owned onsite sewage disposal systems—70 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake direct tributary watershed area.

As indicated in Table C-206, all direct tributary sources combined contribute about 785 pounds of phosphorus annually to Friess Lake during an average year of precipitation. In addition, it is estimated that approximately 900 pounds of total phosphorus are contributed from the upstream indirect tributary watershed area. Therefore, about 1,700 pounds of phosphorus are estimated to enter Friess Lake under existing conditions. These pollutant loads were estimated based on data developed during

Table C-205

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF FRIESS LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 119 acres |
| Direct Tributary Drainage Area | 843 acres |
| Shoreline | 2.3 miles |
| Depth | |
| Maximum | 48 feet |
| Mean | 26.1 feet |
| Volume | 3,105 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 665 persons |
| General Existing Water Quality Conditions: | Generally good, except for occasional lack of oxygen in the hypolimnion and high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.96 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-206

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO FRIESS LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 180 | 25 | 3.2 | 180 | 25 | 3.2 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 70 | 152 | 19.4 | 70 | 152 | 19.4 |
| Rural Land Cover (acres) | 663 | 47 | 6.0 | 663 | 47 | 6.0 |
| Livestock Operations (animal units) | 217 | 501 | 63.8 | 217 | 501 | 63.8 |
| Atmospheric Contribution (acres of receiving surface water) | 119 | 60 | 7.6 | 119 | 60 | 7.6 |
| Total | – | 785[c] | 100.0 | – | 785[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

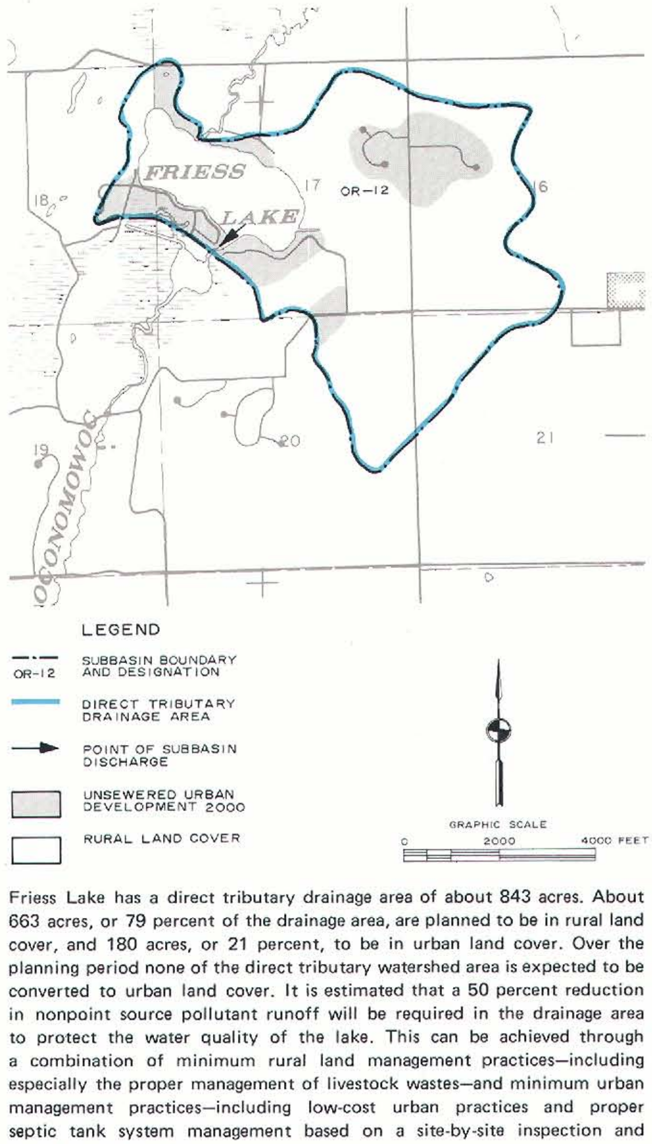
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated or the year 2000 anticipated phosphorus load of 900 pounds per year contributed by the upstream drainage area of the Oconomowoc River.*

*Source: SEWRPC.*

Map C-69

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF FRIESS LAKE: 2000




Friess Lake has a direct tributary drainage area of about 843 acres. About 663 acres, or 79 percent of the drainage area, are planned to be in rural land cover, and 180 acres, or 21 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 50 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

detailed field studies—conducted during a period of below average precipitation and general pollutant source loading estimates for the lake watershed for average or typical year conditions. Also, as indicated in Table C-206, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The observed total phosphorus concentration during study year 1976 spring overturn was 0.04 milligram per liter (mg/l), which is also the expected year 2000 steady state spring phosphorus concentration. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Friess Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-207, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. When this problem is confirmed through further local study, the specific lake restoration or rehabilitation procedures which are appropriate should be identified for application, often implementation of the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-207, may include nutrient inactivation and hypolimnetic aeration. Chemical treatment to control algae can be used if necessary, but is only a temporary solution to the problem. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Friess Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Friess Lake would entail a total capital cost of about $19,200, and an average annual operation and maintenance cost of about $3,100. The total 50-year present worth cost of these source control measures is $52,100, with an equivalent annual cost of $3,300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $8,100 for nutrient inactivation to $16,200 for hypolimnetic

Table C-207

WATER QUALITY MANAGEMENT MEASURES FOR FRIESS LAKE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | | | | | | | | | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | |
| Livestock Waste Control[b] | $ 19,100 | $ 1,600 | $ 14,300 | $ 19,200 | $ 33,500 | $ 900 | $ 1,200 | $ 2,100 | | |
| Minimum Rural Conservation Practices | 100 | 1,200 | 100 | 14,400 | 14,500 | Minimal | 900 | 900 | | |
| Low Cost Urban Land Management Practices | Minimal | 300 | Minimal | 4,100 | 4,100 | Minimal | 300 | 300 | | |
| Total | 19,200 | 3,100 | 14,400 | 37,700 | 52,100 | 900 | 2,400 | 3,300 | | 90 |
| Hypolimnetic Aeration[c] | 16,200 | 400 | 12,100 | 6,300 | 18,400 | 800 | 400 | 1,200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 8,100 to 11,900 | -- | 6,100 to 8,900 | -- | 6,100 to 8,900 | 400 to 600 | -- | 400 to 600 | Accelerate lake improvement; prevent release of nutrient from sediment; remove nutrients from water body | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Friess Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Friess Lake drainage basin include a capital cost over the period of 1975-2000 of $315,000, an average annual operation and maintenance cost of $5,700, and a total 50-year present worth cost of $372,500.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

*Source: SEWRPC*

aeration. The total present worth of these alternatives would range from $6,100 for nutrient inactivation to $18,400 for hypolimnetic aeration.

Golden Lake

Golden Lake is a 250-acre lake located in the Town of Summit in Waukesha County. The lake drains to the Rock River via numerous marshlands and tributary streams. Certain geomorphological characteristics of Golden Lake are set forth in Table C-208, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-70 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-70, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 84 privately owned onsite sewage disposal systems—54 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-209, all direct sources combined contribute about 330 pounds of phosphorus annually to Golden Lake. The major source of phosphorus in the lake watershed is malfunctioning septic systems. Also, as indicated in Table C-209, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000

Table C-208

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF GOLDEN LAKE

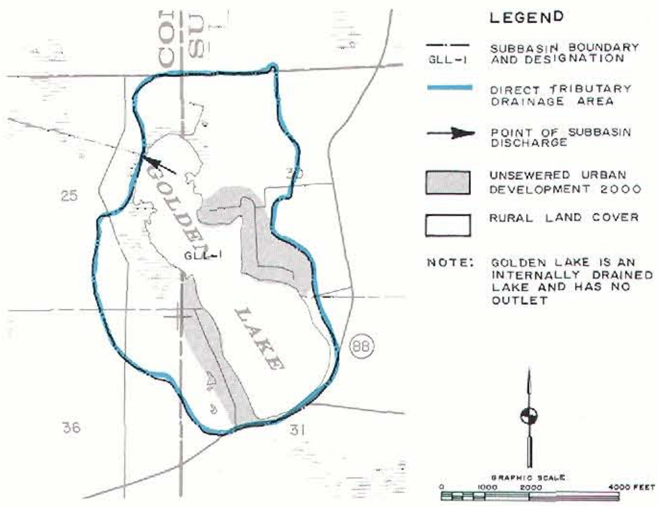
| Characteristic | Description |
|---|---|
| Surface Area | 250 acres |
| Direct Tributary Drainage Area | 476 acres |
| Shoreline | 3.40 miles |
| Depth | |
| Maximum | 44 feet |
| Mean | 13.8 feet |
| Volume | 3,450 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 269 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; some macrophyte growth; occasional lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Map C-70

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF GOLDEN LAKE: 2000




Golden Lake has a direct tributary drainage area of about 476 acres. About 387 acres, or 81 percent of the drainage area, are planned to be in rural land cover, and 89 acres, or 19 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-209

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO GOLDEN LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 89 | 13 | 3.9 | 89 | 13 | 3.9 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 54 | 156 | 47.1 | 54 | 156 | 47.1 |
| Rural Land Cover (acres) | 387 | 37 | 11.2 | 387 | 37 | 11.2 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 250 | 125 | 37.8 | 250 | 125 | 37.8 |
| Total | – | 331 | 100.0 | – | 331 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Golden Lake which do not exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. Certain low-cost control measures are recommended in the Golden Lake watershed to ensure continued high quality water. These measures are set forth in Table C-210, along with the associated costs and anticipated effectiveness. Measures to control septic system contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake and protect public health. Other needed measures include: minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-210, may include hypolimnetic aeration and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Golden Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Golden Lake would entail a total capital cost of about $100 and an average annual operation and maintenance cost of about $800. The total 50-year present worth cost of these source control measures is $10,500, with an equivalent annual cost of $600. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $16,800 for hypolimnetic aeration to $483,900 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $18,900 for hypolimnetic aeration to $361,600 for dredging.

**Table C-210**

**WATER QUALITY MANAGEMENT MEASURES FOR GOLDEN LAKE IN WAUKESHA COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ 100 | $ 700 | $ 100 | $ 8,400 | $ 8,500 | Minimal | $ 500 | $ 500 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 2,000 | 2,000 | Minimal | 100 | 100 | | |
| Total | 100 | 800 | 100 | 10,400 | 10,500 | Minimal | 600 | 600 | | 40 |
| Macrophyte Harvesting[b] | 23,300 | 3,200 | 17,400 | 50,400 | 67,800 | 1,100 | 3,200 | 4,300 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 16,800 | 400 | 12,600 | 6,300 | 18,900 | 800 | 400 | 1,000 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Dredging[d,e] | 483,900 | – | 361,600 | – | 361,600 | 22,900 | – | 22,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Golden Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Golden Lake drainage basin include a capital cost over the period of 1975-2000 of $243,000, an average annual operation and maintenance cost of $3,100, and a total 50-year present worth cost of $241,900.*

[b] *Cost estimated to harvest macrophytes from the 25 acres of Golden Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 13.8 feet.*

[e] *The costs for dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged.*

*Source: SEWRPC.*

Hunter's Lake

Hunter's Lake is a 65-acre lake located in the Town of Ottawa in Waukesha County. The lake drains to Scuppernong Creek. Certain geomorphological characteristics of Hunter's Lake are set forth in Table C-211, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-71 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-71, a portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 103 privately owned onsite sewage disposal systems—80 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. Part of the lake watershed area—but not development along the lake shore—is proposed to be served by sanitary sewer service under planned year 2000 conditions.

As indicated in Table C-212, all direct sources combined contribute about 700 pounds of phosphorus annually to Hunter's Lake. An additional 420 pounds of phosphorus is added annually from Waterville Pond. The major direct source of phosphorus in the immediate lake watershed is malfunctioning septic tank systems. Also, as indicated in Table C-212, land uses in the watershed are not expected to change significantly under planned year 2000 land cover conditions. Direct phosphorus loads to the lake will be reduced to about 650 pounds annually as a result of the provision of sanitary sewers. Loads from Waterville Pond are expected to be reduced to about 240 pounds

Table C-211

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF HUNTER'S LAKE

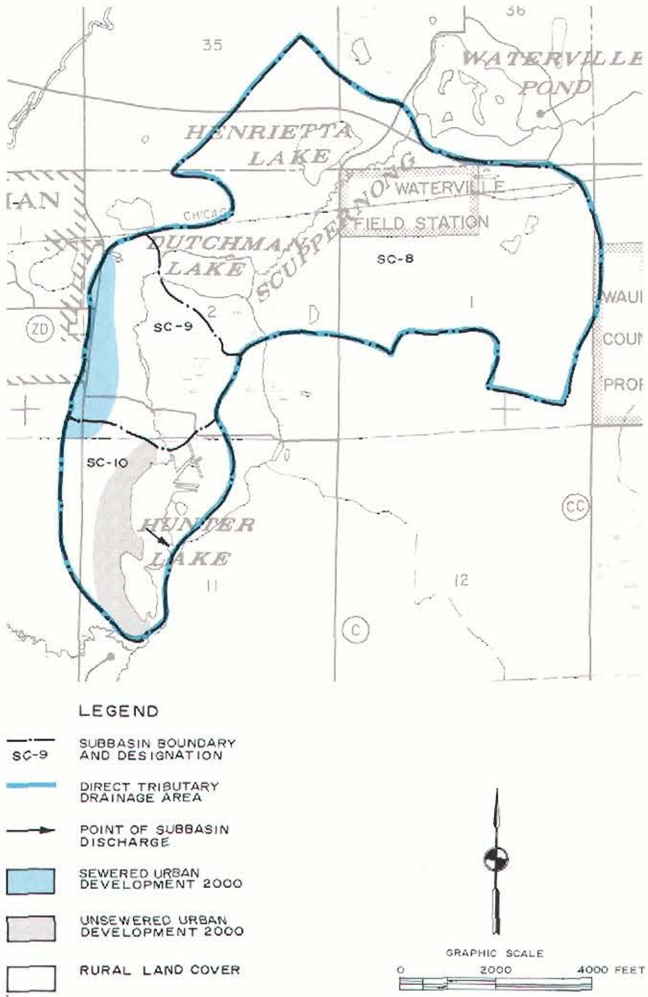
| Characteristic | Description |
|---|---|
| Surface Area | 65 acres |
| Direct Tributary Drainage Area | 1,222 acres |
| Shoreline | 1.87 miles |
| Depth | |
| Maximum | 36 feet |
| Mean | 20 feet |
| Volume | 1,300 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 373 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; some macrophyte growth |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.62 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-71

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF HUNTER'S LAKE: 2000




Hunter's Lake has a direct tributary drainage area of about 1,222 acres. About 1,023 acres, or 84 percent of the drainage area, are planned to be in rural land cover, and 199 acres, or 16 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-212

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO HUNTER'S LAKE: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 199 | 121 | 17.0 | 199 | 121 | 18.8 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 80 | 232 | 32.5 | 57 | 165 | 25.6 |
| Rural Land Cover (acres) | 1,023 | 161 | 22.7 | 1,023 | 161 | 25.0 |
| Livestock Operations (animal units) | 25 | 165 | 23.2 | 25 | 165 | 25.6 |
| Atmospheric Contribution (acres of receiving surface water) | 65 | 32 | 4.6 | 65 | 32 | 5.0 |
| Total | – | 711[c] | 100.0 | – | 644[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 420 pounds per year or the year 2000 anticipated phosphorus load of 240 pounds per year contributed by the upstream drainage of Waterville Pond.*

*Source: SEWRPC.*

annually as a result of lake quality management for the Waterville Lake watershed. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.03 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Hunter's Lake which meet the recommended level for recreational use and for the maintenance of a warmwater fishery in the year 2000.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An

Table C-213

**WATER QUALITY MANAGEMENT MEASURES FOR HUNTER'S LAKE IN WAUKESHA COUNTY**

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | -- | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 2,200 | $ 200 | $ 1,600 | $ 2,200 | $ 3,800 | $ 100 | $ 100 | $ 200 | | |
| Minimum Rural Conservation Practices | 200 | 1,800 | 200 | 21,800 | 22,000 | < 100 | 1,400 | 1,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 300 | Minimal | 4,800 | 4,800 | Minimal | 300 | 300 | | 50[a] |
| Total | 2,400 | 2,300 | 1,800 | 28,800 | 30,600 | 200 | 1,800 | 1,900 | | |
| Macrophyte Harvesting[d] | 4,700 | 700 | 3,500 | 11,000 | 14,500 | 200 | 700 | 900 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[e] | 9,000 | 200 | 6,700 | 3,200 | 9,900 | 400 | 200 | 600 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 4,500 | – | 3,400 | – | 3,400 | 200 | – | 200 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,h] | 130,000 | – | 97,100 | – | 97,100 | 6,200 | – | 6,200 | Accelerate lake improvement; prevent release of nutrients from sediment, reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Hunter's Lake drainage basin include a capital cost over the period of 1975-2000 of $596,000, an average annual operation and maintenance cost of $4,500, and a total 50-year present worth cost of $404,400.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Hunter's Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Hunter's Lake drainage basin include a capital cost over the period of 1975-2000 of $265,500, an average annual operation and maintenance cost of $3,000, and a total 50-year present worth cost of $245,700.*

[d] *Cost estimated to harvest macrophytes from the 5 acres of Hunter's Lake subject to excessive macrophyte growth.*

[e] *Cost estimated to aerate the entire hypolimnion of the lake.*

[f] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-213, along with the associated costs and anticipated effectiveness. Measures to control livestock wastes appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-213 may include nutrient inactivation, hypolimnetic aeration, and sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Hunter's Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Hunter's Lake would entail a total capital cost of about $2,400, and an average annual operation and maintenance cost of about $2,300. The total 50-year present worth cost of these source control measures is $30,600, with an equivalent annual cost of $1,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,500 for nutrient inactivation to $130,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $3,400 for nutrient inactivation to $97,100 for sediment covering.

### Lake Keesus

Lake Keesus is a 237-acre lake located in the Town of Merton in Waukesha County. The lake drains to the west through a marsh to the Oconomowoc River. Certain geomorphological characteristics of Lake Keesus are set forth in Table C-214, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-72 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-72, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 212 privately owned onsite sewage disposal systems—117 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-215, all direct sources combined contribute about 5,200 pounds of phosphorus annually to Lake Keesus. The major source of phosphorus in the lake watershed is livestock operations. Also, as indicated in Table C-215, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.23 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Keesus which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended mea-

Table C-214

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE KEESUS

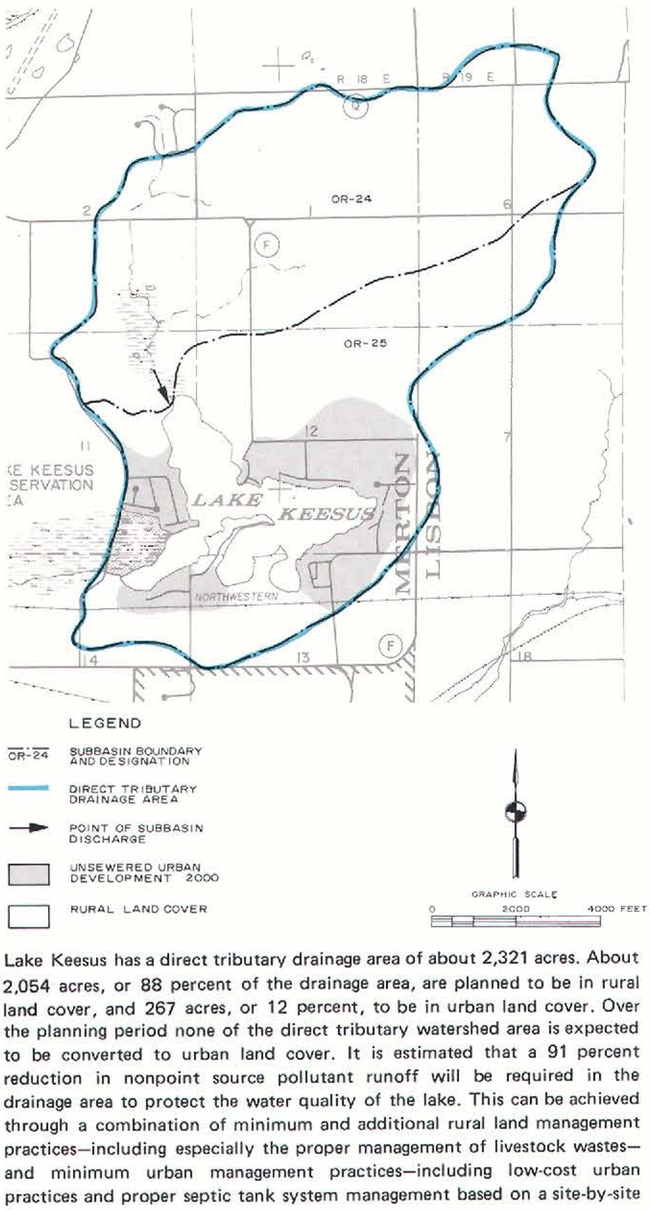
| Characteristic | Description |
|---|---|
| Surface Area | 237 acres |
| Direct Tributary Drainage Area | 2,321 acres |
| Shoreline | 5.0 miles |
| Depth | |
| Maximum | 42 feet |
| Mean | 16.7 feet |
| Volume | 3,958 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 744 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.51 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Map C-72

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE KEESUS: 2000




Lake Keesus has a direct tributary drainage area of about 2,321 acres. About 2,054 acres, or 88 percent of the drainage area, are planned to be in rural land cover, and 267 acres, or 12 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 91 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum and additional rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

sures was identified. These measures are set forth in Table C-216, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands, and low-cost measures to reduce pollutant runoff from urban lands.

## Table C-215

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE KEESUS: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 267 | 35 | 0.7 | 267 | 35 | 0.7 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 117 | 339 | 6.5 | 117 | 339 | 6.5 |
| Rural Land Cover (acres) | 2,054 | 189 | 3.6 | 2,054 | 189 | 3.6 |
| Livestock Operations (animal units) | 682 | 4,500 | 86.9 | 682 | 4,500 | 86.9 |
| Atmospheric Contribution (acres of receiving surface water) | 237 | 118 | 2.3 | 237 | 118 | 2.3 |
| Total | – | 5,181 | 100.0 | – | 5,181 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration and rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-216 may include nutrient inactivation, sediment covering, and hypolimnetic aeration. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lake Keesus requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lake Keesus would entail a total capital cost of about \$60,400, and an average annual operation and maintenance cost of about \$9,200. The total 50-year present worth cost of these source control measures is \$155,500, with an equivalent annual cost of \$9,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from \$23,700 for nutrient inactivation to \$474,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from \$17,700 for nutrient inactivation to \$354,200 for sediment covering.

Table C-216

WATER QUALITY MANAGEMENT MEASURES FOR LAKE KEESUS IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis — Present Worth: 1975-2025: Capital | Present Worth: 1975-2025: Operation and Maintenance | Present Worth: 1975-2025: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: 1975-2025: Operation and Maintenance | Equivalent Annual: 1975-2025: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 60,000 | $ 5,100 | $ 44,900 | $ 60,200 | $ 105,100 | $ 2,800 | $ 3,800 | $ 6,600 | | |
| Minimum Rural Land Management Practices | 400 | 3,800 | 400 | 46,100 | 46,500 | < 100 | 2,900 | 3,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 300 | Minimal | 3,900 | 3,900 | Minimal | 300 | 300 | | 90 |
| Total | 60,400 | 9,200 | 45,300 | 110,200 | 155,500 | 2,900 | 7,000 | 9,900 | | |
| Macrophyte Harvesting[b] | 32,600 | 4,600 | 24,400 | 72,500 | 96,900 | 1,500 | 4,600 | 1,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 24,000 | 600 | 17,900 | 9,500 | 27,400 | 1,100 | 600 | 1,700 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 23,700 | -- | 17,700 | – | 17,700 | 1,100 | – | 1,100 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 474,000 | – | 354,200 | – | 354,200 | 22,500 | – | 22,500 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lake Keesus. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lake Keesus drainage basin include a capital cost over the period of 1975-2000 of $526,500, an average annual operation and maintenance cost of $7,600, and a total 50-year present worth cost of $554,000.*

[b] *Cost estimated to harvest macrophytes from the 35 acres of Lake Keesus subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs of sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

Lac La Belle

Lac La Belle is a 1,117-acre lake located in the Town of Oconomowoc in Waukesha County. The Lake drains to the Oconomowoc River. Certain geomorphological characteristics of Lac La Belle are set forth in Table C-217, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[18,19] Map C-73 presents a graphic summary of the proposed year 2000 land cover in the direct tributary lake watershed. As shown on Map C-73, a large portion of the urban land in the direct tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 722 privately owned onsite sewage disposal systems—80 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake direct tributary watershed area.

As indicated in Table C-218, all direct tributary sources combined contribute about 4,200 pounds of phosphorus annually to Lac La Belle during an average year of precipitation. An estimated additional 3,000 pounds of total phosphorus enters the lake annually as discharge from Fowler Lake via the Oconomowoc River. Therefore, about 7,200 pounds of total phosphorus per year are estimated to enter Lac La Belle under existing conditions. These pollutant loads were estimated based on data developed during detailed field studies conducted during a period of below average precipitation and general pollutant source loading estimates for the lake watershed for average or typical year conditions. Also, as indicated in Table C-218, urban land uses in the watershed are

[18] *See separately published SEWRPC Community Assistance Planning Report on the Water Quality Management for Lac La Belle, Waukesha County, for a more detailed discussion of the findings and recommendation of the detailed field studies.*

[19] *Report on Lac La Belle, National Eutrophication Survey, U.S. Environmental Protection Agency, 1975.*

Table C-217

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAC LA BELLE

| Characteristic | Description |
|---|---|
| Surface Area | 1,117 acres |
| Direct Tributary Drainage Area | 6,447 acres |
| Shoreline | 8.70 miles |
| Depth | |
| Maximum | 38 feet |
| Mean | 11.6 feet |
| Volume | 12,957 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 3,049 persons |
| General Existing Water Quality Conditions: | Nuisance macrophyte growth; low transparency |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-218

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAC LA BELLE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,411 | 260 | 6.2 | 2,573 | 446 | 10.7 |
| Land under Development–Construction Activities (acres) | 45 | 1,350 | 32.0 | 45 | 1,350 | 32.3 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 80 | 174 | 4.1 | 15 | 32 | 0.8 |
| Rural Land Cover (acres) | 4,991 | 338 | 8.0 | 3,829 | 252 | 6.0 |
| Livestock Operations (animal units) | 583.5 | 1,540 | 36.5 | 583.5 | 1,540 | 36.8 |
| Atmospheric Contribution (acres of receiving surface water) | 1,117 | 558 | 13.2 | 1,117 | 558 | 13.4 |
| Total | – | 4,220[c] | 100.0 | – | 4,178[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 3,000 pounds per year or the year 2000 anticipated phosphorus load of 1,000 pounds per year contributed by the drainage from the upstream Oconomowoc River watershed.*

*Source: SEWRPC.*

expected to increase by nearly 100 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be reduced slightly to about 5,200 pounds. The observed total phosphorus concentration during study year 1976 spring overturn was 0.04 milligram per liter (mg/l) which is also the expected steady state spring phosphorus concentration under existing conditions. Under planned future land use conditions, a spring phosphorus concentration of 0.03 mg/l may be expected. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lac La Belle which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

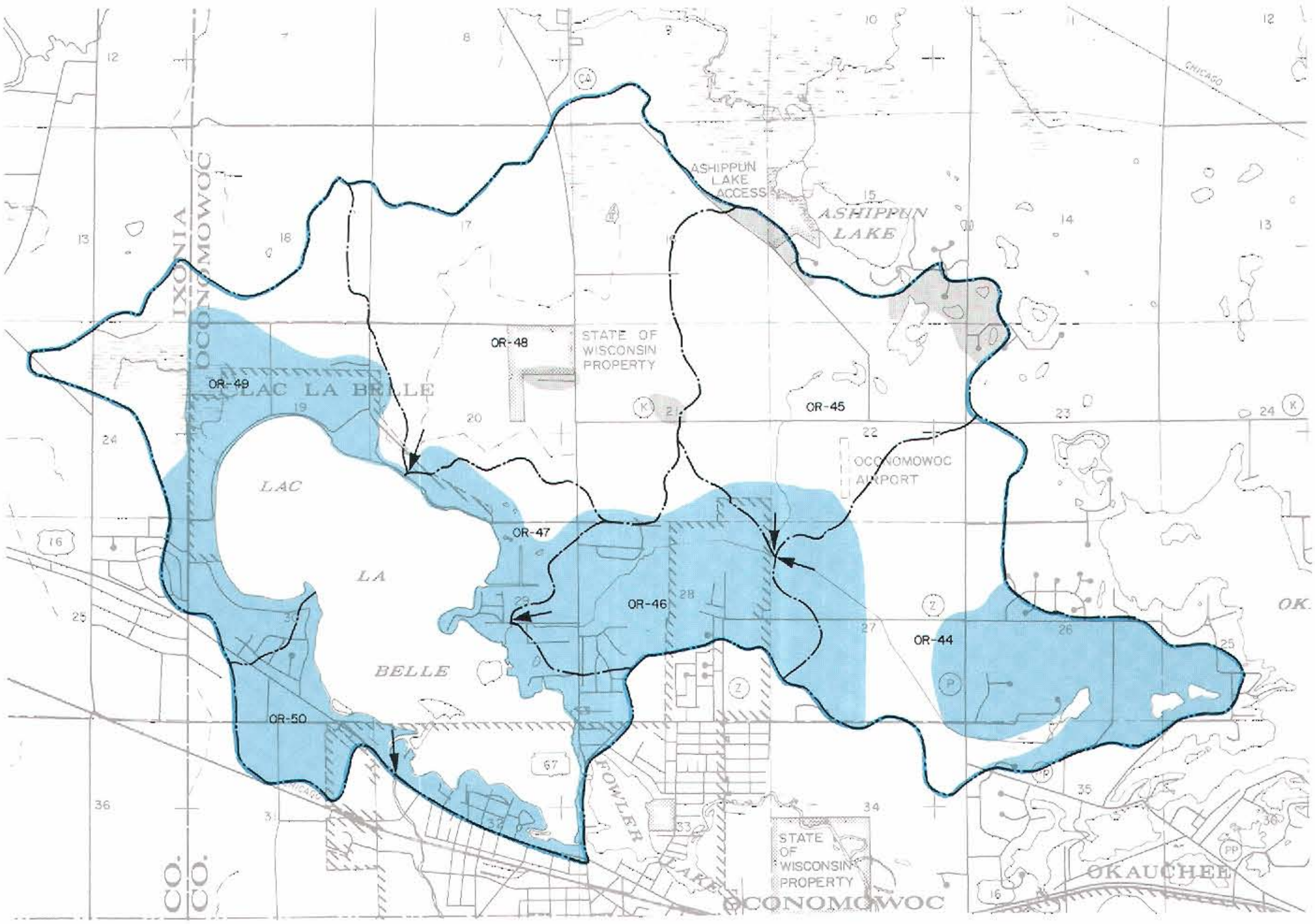
The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-219, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. When this problem is confirmed through further local study, the specific lake restoration or rehabilitation procedures which are appropriate should be identified for application after implementation of the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-219 may include macrophyte harvesting and sediment coverng. Chemical treatment to control algae can be used if necessary, but only as a temporary solution to the problem. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Lac La Belle requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lac La Belle would entail a total capital cost of about $2,838,400, and an average annual operation and maintenance cost of about $40,400. The total 50-year present worth cost of these source control measures is

## Map C-73

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAC LA BELLE: 2000




LEGEND

- OR-7 — SUBBASIN BOUNDARY AND DESIGNATION
- DIRECT TRIBUTARY DRAINAGE AREA
- POINT OF SUBBASIN DISCHARGE
- SEWERED URBAN DEVELOPMENT 2000
- UNSEWERED URBAN DEVELOPMENT 2000
- RURAL LAND COVER

GRAPHIC SCALE
0 2000 4000 FEET

Lac La Belle has a direct tributary drainage area of about 6,447 acres. About 3,829 acres, or 59 percent of the drainage area, are planned to be in rural land cover, and 2,618 acres, or 41 percent, to be in urban land cover. Over the planning period an average of about 45 acres may be expected to be converted annually to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-219

WATER QUALITY MANAGEMENT MEASURES FOR LAC LA BELLE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | -- | -- | -- | -- | -- | -- | -- | -- | Protect public health and drinking water supplies; reduce nutrient concentrations | -- |
| Septic Tank System Management[c] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 50 |
| Livestock Waste Control | $ 65,500 | $ 5,400 | $ 49,000 | $ 62,700 | $ 111,700 | $ 3,100 | $ 4,000 | $ 7,100 | | |
| Minimum Rural Conservation Practices | 900 | 7,800 | 700 | 95,400 | 96,100 | < 100 | 6,100 | 6,200 | | |
| Construction Erosion Control Practices[d] | 2,772,000 | 24,000 | 2,080,600 | 378,300 | 2,458,900 | 132,000 | 24,000 | 156,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 3,200 | Minimal | 46,800 | 46,800 | Minimal | 3,000 | 3,000 | | |
| Total | 2,838,400 | 40,400 | 2,130,300 | 583,200 | 2,713,500 | 135,200 | 37,100 | 172,300 | | |
| Macrophyte Harvesting[e] | 46,600 | 6,500 | 34,800 | 102,500 | 137,300 | 2,200 | 6,500 | 8,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Continued Fish Management | Minimal | | Minimal | | | Minimal | | | Improve water clarity, recreational use, and aesthetic enhancement | No additional reduction |
| Sediment Covering[f,g] | 2,234,000 | -- | 1,669,500 | -- | 1,669,500 | 105,900 | -- | 105,900 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Lac La Belle drainage basin include a capital cost over the period of 1975-2000 of $2,680,000, an average annual operation and maintenance cost of $27,000, and a total 50-year present worth cost of $1,927,700.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lac La Belle. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lac La Belle drainage basin include a capital cost over the period of 1975-2000 of $67,500, an average annual operation and maintenance cost of $3,500 and a total 50-year present worth cost of $153,600.*

[d] *Cost estimated to control erosion from the estimated 60 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 50 acres of Lac La Belle subject to excessive macrophyte growth.*

[f] *Costs estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *The costs of sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC*

$2,713,500, with an equivalent annual cost of $172,300. If, in addition, management or rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $46,600 for macrophyte harvesting to $2,234,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $137,300 for macrophyte harvesting to $1,669,500 for sediment covering.

La Grange Lake

La Grange Lake is a 55-acre lake located in the Town of La Grange in Walworth County. The lake drains to Whitewater Creek. Certain geomorphological characteristics of La Grange Lake are set forth in Table C-220, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-74 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-74, no significant areas of urban land developed are expected to exist in the tributary watershed area by year 2000. As of 1975, less than five privately owned onsite sewage disposal systems—two of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-221, all direct sources combined contribute about 1,100 pounds of phosphorus annually to La Grange Lake. The major source of phosphorus in the lake watershed is livestock contributions. Also as indicated in Table C-221, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake drainage basin characteristics, is 0.22 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in La Grange Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-222, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

Table C-220

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LA GRANGE LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 55 acres |
| Direct Tributary Drainage Area | 586 acres |
| Shoreline | 1.80 miles |
| Depth | |
| Maximum | 4.0 feet |
| Mean | 2.0 feet |
| Volume | 110 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 50 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; dense macrophyte growth; high nutrient concentrations; winter fishkill |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Table C-221

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LA GRANGE LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 161 | 20 | 1.8 | 161 | 20 | 1.8 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | < 5 | 6 | 1.0 | < 5 | 6 | 1.0 |
| Rural Land Cover (acres) | 425 | 51 | 4.5 | 425 | 51 | 4.5 |
| Livestock Operations (animal units) | 155 | 1,023 | 90.3 | 155 | 1,023 | 90.3 |
| Atmospheric Contribution (acres of receiving surface water) | 55 | 27 | 2.4 | 55 | 27 | 2.4 |
| Total | – | 1,127 | 100.0 | – | 1,127 | 100.0 |

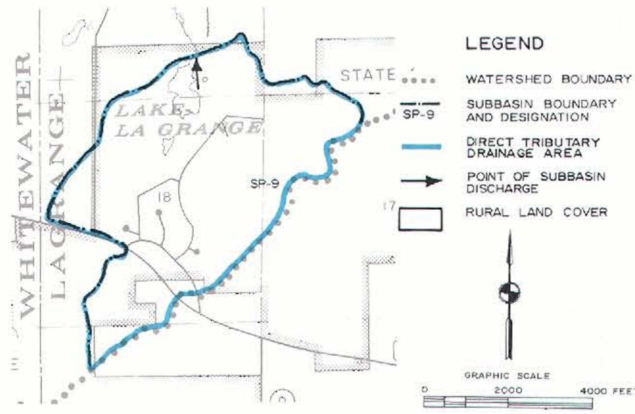
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-74

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LA GRANGE LAKE: 2000




Lake La Grange has a direct tributary drainage area of about 586 acres. About 425 acres, or 73 percent of the drainage area, are planned to be in rural land cover, and 161 acres, or 27 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

## Table C-222

## WATER QUALITY MANAGEMENT MEASURES FOR LA GRANGE LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 65,700 | $ 4,600 | $ 49,100 | $ 54,700 | $ 103,800 | $ 3,100 | $ 3,500 | $ 6,600 | | |
| Minimum Rural Conservation Practices | 2,000 | 6,600 | 1,700 | 33,200 | 34,900 | 100 | 2,100 | 2,200 | | |
| Low Cost Urban Land Management Practices | Minimal | 300 | Minimal | 3,900 | 3,900 | Minimal | 200 | 200 | | |
| Total | 67,700 | 11,500 | 50,800 | 91,800 | 142,600 | 3,200 | 5,800 | 9,000 | | |
| Aeration[b] | 4,000 | 100 | 3,000 | 1,600 | 4,600 | 200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[c,e] | 110,000 | -- | 82,200 | -- | 82,200 | 5,200 | -- | 5,200 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[d,e] | 1,153,300 | -- | 861,900 | -- | 861,900 | 54,700 | -- | 54,700 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of La Grange Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the La Grange Lake drainage basin include a capital cost over the period of 1975-2000 of less than $100, an average annual operation and maintenance cost of less than $100, and a total 50-year present worth cost of $2,000.*

[b] *Cost estimated to aerate 20 acres of the lake.*

[c] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[d] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 2.0 feet.*

[e] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be dredged or filled.*

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-222, may include aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in La Grange Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to La Grange Lake would entail a total capital cost of about $67,700, and an average annual operation and maintenance cost of about $11,500. The total 50-year present worth cost of these source control measures is $142,600, with an equivalent annual cost of $9,000. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,000 for aeration to $1,153,300 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,600 for aeration to $861,900 for dredging.

### Lake Loraine

Lake Loraine is a 133-acre lake located in the Town of Richmond in Walworth County. The lake which lies within the boundaries of the Rock River watershed is internally drained. Certain geomorphological characteristics of Lake Loraine are set forth in Table C-223, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-75 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-75, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 134 privately owned onsite sewage disposal systems—60 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation on the lake watershed area.

As indicated in Table C-224, all direct sources combined contribute about 1,300 pounds of phosphorus annually to Lake Loraine. The major source of phosphorus in the

### Table C-223

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LAKE LORAINE

| Characteristic | Description |
|---|---|
| Surface Area | 133 acres |
| Direct Tributary Drainage Area | 1,415 acres |
| Shoreline | 3.20 miles |
| Depth | |
| Maximum | 7.5 feet |
| Mean | 3.0 feet |
| Volume | 399 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 419 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; frequent fish winterkill; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

lake watershed is livestock waste contributions. Also, as indicated in Table C-224, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.09 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lake Loraine which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-225, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pol-

### Table C-224

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LAKE LORAINE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 140 | 23 | 1.8 | 140 | 23 | 1.8 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 60 | 174 | 13.7 | 60 | 174 | 13.7 |
| Rural Land Cover (acres) | 1,275 | 125 | 9.8 | 1,275 | 125 | 9.8 |
| Livestock Operations (animal units) | 133 | 878 | 69.4 | 133 | 878 | 69.4 |
| Atmospheric Contribution (acres of receiving surface water) | 133 | 67 | 5.3 | 133 | 67 | 5.3 |
| Total | – | 1,267 | 100.0 | – | 1,267 | 100.0 |

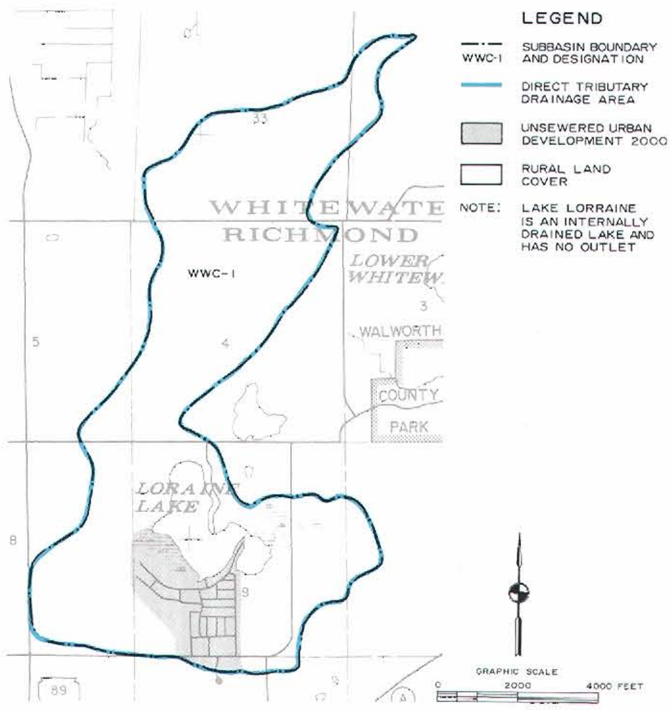
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

### Map C-75

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LAKE LORAINE: 2000




Lake Loraine has a direct tributary drainage area of about 1,415 acres. About 1,275 acres, or 90 percent of the drainage area, are planned to be in rural land cover, and 140 acres, or 10 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 78 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-225

WATER QUALITY MANAGEMENT MEASURES FOR LAKE LORAINE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis, Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Economic Analysis, Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 11,700 | $ 1,000 | $ 8,800 | $ 11,700 | $ 20,500 | $ 600 | $ 700 | $ 1,300 | | |
| Minimum Rural Conservation Practices | 300 | 2,200 | 200 | 27,200 | 27,400 | Minimal | 1,700 | 1,700 | | |
| Low Cost Urban Land Management Practices | Minimal | 200 | Minimal | 3,400 | 3,400 | Minimal | 200 | 200 | | 80 |
| Total | 12,000 | 3,400 | 9,000 | 42,300 | 51,300 | 600 | 2,600 | 3,200 | | |
| Macrophyte Harvesting[b] | 31,700 | 4,400 | 23,700 | 69,400 | 93,100 | 1,500 | 4,400 | 5,900 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[c] | 10,000 | 300 | 7,500 | 3,900 | 11,400 | 500 | 200 | 700 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 13,300 | – | 9,900 | – | 9,900 | 600 | – | 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 266,000 | – | 198,800 | – | 198,800 | 12,600 | – | 12,600 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 2,574,300 | – | 1,923,800 | – | 1,923,800 | 122,000 | – | 122,000 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Loraine Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Loraine Lake drainage basin include a capital cost over the period of 1975-2000 of $270,000, an average annual operation and maintenance cost of $4,600, and a total 50-year present worth cost of $309,400.*

[b] *Cost estimated to harvest macrophytes from the 34 acres of Loraine Lake subject to excessive macrophyte growth.*

[c] *Cost to aerate 50 acres of the surface area of the lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

[g] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 3.0 feet.*

*Source: SEWRPC.*

lutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-225 may include nutrient inactivation, aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lake Loraine requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lake Loraine would entail a total capital cost of about $12,000, and an average annual operation and maintenance cost of about $3,400. The total 50-year present worth cost of these source control measures is $51,300, with an equivalent annual cost of $3,200. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $10,000 for aeration to $2,574,300 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $9,900 for nutrient inactivation to $1,923,800 for dredging.

## Lower Genesee Lake

Lower Genesee Lake is a 66-acre lake located in the Town of Summit in Waukesha County. The lake is internally drained. Certain geomorphological characteristics of Lower Genesee Lake are set forth in Table C-226, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-76 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-76, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 69 privately owned onsite sewage disposal systems—24 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-227, all sources combined contribute about 135 pounds of phosphorus annually to Lower Genesee Lake. The major source of phosphorus in the lake watershed is a result of septic tank system operations. Also, as indicated in Table C-227, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total

### Table C-226

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LOWER GENESEE LAKE

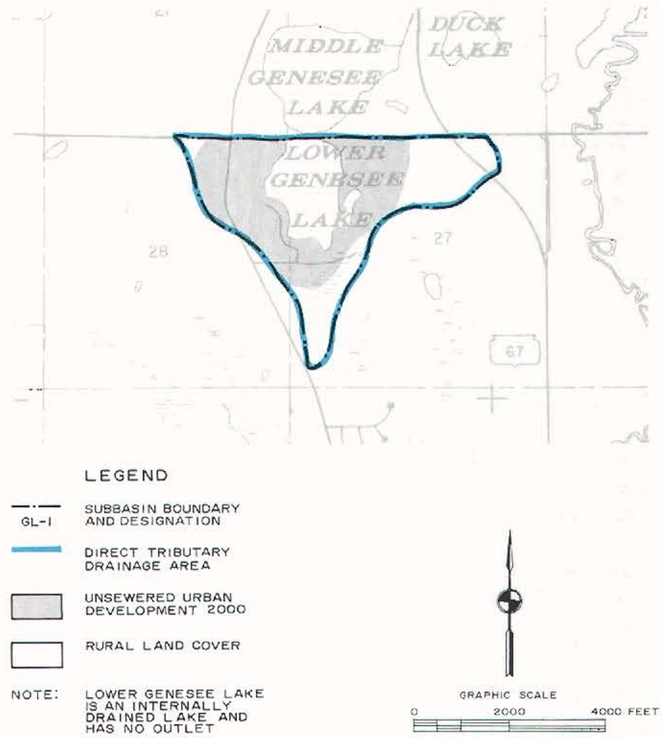
| Characteristic | Description |
|---|---|
| Surface Area | 66 acres |
| Direct Tributary Drainage Area | 273 acres |
| Shoreline | 1.40 miles |
| Depth | |
| Maximum | 44 feet |
| Mean | 18.3 feet |
| Volume | 1,208 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 221 persons |
| General Existing Water Quality Conditions: | Some macrophyte growth; occasional lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Map C-76

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LOWER GENESEE LAKE: 2000




Lower Genesee Lake has a direct tributary drainage area of about 273 acres. About 195 acres, or 71 percent of the drainage area, are planned to be in rural land cover, and 78 acres, or 29 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

### Table C-227

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LOWER GENESEE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 87 | 14 | 10.4 | 78 | 14 | 10.4 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 24 | 69 | 51.1 | 24 | 69 | 51.1 |
| Rural Land Cover (acres) | 186 | 19 | 14.1 | 195 | 19 | 14.1 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 66 | 33 | 24.4 | 66 | 33 | 24.4 |
| Total | – | 135 | 100.0 | – | 135 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lower Genesee Lake which do not exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake was made, and a set of recommended measures was identified. These measures are set forth in Table C-228, along with the associated costs and anticipated effectiveness. Measures to control septic tank system contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake while reducing public health hazards. Other needed measures include: minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. An alternative restoration measure as set forth in Table C-228 may include hypolimnetic aeration. The feasibility of this measure would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lower Genesee Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lower Genesee Lake would entail a total capital cost of less than $100, and an average annual operation and maintenance cost of about $400. The total 50-year present worth cost of these source control measures is $6,200, with an equivalent annual cost of $500. If, in addition, rehabilitation techniques are found necessary, the capital cost of hypolimnetic aeration would be $8,000. The total present worth cost of hypolimnetic aeration would be $9,200.

Lower Nashotah Lake

Lower Nashotah Lake is a 90-acre lake located in the Town of Summit in Waukesha County. The lake drains to the Bark River via the Nemahbin Lakes. Certain geo-

**Table C-228**

**WATER QUALITY MANAGEMENT MEASURES FOR LOWER GENESEE LAKE IN WAUKESHA COUNTY**

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 50 |
| Minimum Rural Conservation Practices[b] | $ < 100 | $ 300 | $ < 100 | $ 4,200 | $ 4,300 | $ < 100 | $ 300 | $ 400 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 1,900 | 1,900 | Minimal | 100 | 100 | | |
| Total | <100 | 400 | 100 | 6,100 | 6,200 | 100 | 400 | 500 | | |
| Macrophyte Harvesting[b] | 3,700 | 500 | 2,800 | 7,900 | 10,700 | 200 | 500 | 700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 8,000 | 200 | 6,000 | 3,200 | 9,200 | 400 | 200 | 600 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lower Genesee Lake. However, because septic tank system management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lower Genesee Lake drainage basin include a capital cost over the period of 1975-2000 of $108,000, an average annual operation and maintenance cost of $2,400, and a total 50-year present worth cost of $139,100.*

[b] *Cost estimated to harvest macrophytes from the 4 acres of Lower Genesee Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

*Source: SEWRPC*

morphological characteristics of Lower Nashotah Lake are set forth in Table C-229, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-77 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-77, all of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 74 privately owned onsite sewage disposal systems—26 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the watershed area.

As indicated in Table C-230, all direct sources combined contribute about 150 pounds of phosphorus annually to Lower Nashotah Lake. The major source of phosphorus in the lake watershed is septic tank systems. An additional 300 pounds is contributed annually as inflow from Upper Nashotah Lake. Also as indicated in Table C-230, land uses in the watershed are not expected to change significantly under planned year 2000 land cover conditions. Annual total direct phosphorus loadings to the lake are expected to be reduced to about 70 pounds as a result of the provision of sanitary sewer service. The inflow load from Upper Nashotah Lake is expected to be reduced to about 40 pounds per year as a result of phosphorus controls recommended for the Upper Nashotah Lake watershed. Thus, in year 2000, atmospheric loadings of phosphorus are expected to be the primary direct tributary source of phosphorus in Lower Nashotah Lake. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.05 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lower Nashotah Lake which meet the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-231, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contribution include: the provision of sanitary sewer service, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

### Table C-229

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LOWER NASHOTAH LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 90 acres |
| Direct Tributary Drainage Area | 185 acres |
| Shoreline | 2.30 miles |
| Depth | |
| Maximum | 43 feet |
| Mean | 20 feet |
| Volume | 1,800 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 237 persons |
| General Existing Water Quality Conditions: | Generally good, although the hypolimnion is frequently devoid of oxygen |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

### Table C-230

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LOWER NASHOTAH LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 108 | 19 | 12.7 | 108 | 19 | 26.2 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 26 | 75 | 51.6 | – | – | – |
| Rural Land Cover (acres) | 77 | 7 | 4.9 | 77 | 7 | 10.2 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 90 | 45 | 30.8 | 90 | 45 | 63.6 |
| Total | – | 146[c] | 100.0 | – | 71[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

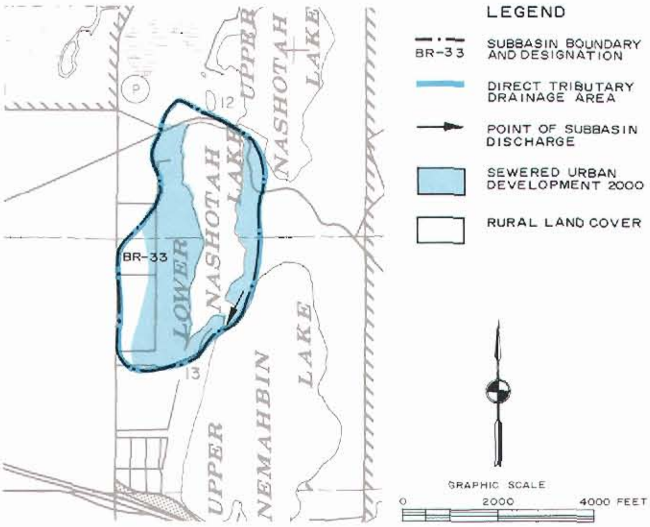
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated and the year 2000 anticipated phosphorus load of 300 pounds per year and 40 pounds per year, respectively, contributed by the drainage from Upper Nashotah Lake.*

*Source: SEWRPC.*

Map C-77

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LOWER NASHOTAH LAKE: 2000**




Lower Nashotah Lake has a direct tributary drainage area of about 185 acres. About 77 acres, or 42 percent of the drainage area, are planned to be in rural land cover, and 108 acres, or 58 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices—should be implemented in the lake drainage area.

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-231 may include hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lower Nashotah Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lower Nashotah Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $300. The total 50-year present worth cost of these source control measures is $4,300, with an equivalent annual cost of $300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $5,400 for nutrient inactivation to $180,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $4,000 for nutrient inactivation to $134,500 for sediment covering.

## Lower Nemahbin Lake

Lower Nemahbin Lake is a 271-acre lake located in the Town of Summit in Waukesha County. The lake drains to the Bark River. Certain geomorphological characteristics of Lower Nemahbin Lake are set forth in Table C-232, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-78 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality management plan. The delineated tributary drainage area should be refined in a more detailed local lake study. As shown on Map C-78, the majority of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 170 privately owned onsite sewage disposal systems—97 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. The provision of sanitary sewer service is recommended for the lake watershed under planned year 2000 conditions.

As indicated in Table C-233, all direct tributary sources combined contribute about 500 pounds of phosphorus annually to Lower Nemahbin Lake. The major direct source of phosphorus in the lake watershed is septic tank systems. In addition, 9,000 pounds of phosphorus enter Lower Nemahbin Lake from drainage from Upper Nemahbin Lake. Also, as indicated in Table C-233, urban land uses in the watershed are expected to increase by about 100 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be increased to about 900 pounds as a result of the increased construction activities needed for the development of urban land which is encouraged by the provision of sanitary sewer service. Construction activities are expected to be the primary direct source of phosphorus to the lake under anticipated year 2000 conditions. Phosphorus loadings from Upper Nemahbin Lake are expected to be reduced to about 2,800 pounds per year by 2000 as a result of lake watershed management practices recommended for that lake. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.09 milligram per liter (mg/l) and 0.06 mg/l, respectively. The Commission

## Table C-231

## WATER QUALITY MANAGEMENT MEASURES FOR LOWER NASHOTAH LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Economic Analysis: Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Minimum Rural Conservation Practices | $ 100 | $ 100 | $ 100 | $ 1,600 | $ 1,700 | Minimal | $ 100 | $ 100 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Low Cost Urban Land Management Practices | Minimal | 200 | Minimal | 2,600 | 2,600 | Minimal | 200 | 200 | | |
| Total | 100 | 300 | 100 | 4,200 | 4,300 | Minimal | 300 | 300 | | 10 |
| Macrophyte Harvesting[c] | 4,200 | 600 | 3,100 | 9,500 | 12,600 | 200 | 600 | 800 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[d] | 10,800 | 300 | 8,100 | 4,700 | 12,800 | 500 | 300 | 800 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[e] | 5,400 to 9,000 | – | 4,000 to 6,700 | – | 4,000 to 6,700 | 300 to 400 | – | 300 to 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[f,g] | 180,000 | – | 134,500 | – | 134,500 | 8,500 | – | 8,500 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Lower Nashotah Lake drainage basin include a capital cost over the period of 1975-2000 of $296,000, an average annual operation and maintenance cost of $2,200, and a total 50-year present worth cost of $200,800.*

[c] *Cost estimated to harvest macrophytes from the 4.5 acres of Lower Nashotah Lake subject to excessive macrophyte growth.*

[d] *Cost estimated to aerate the entire hypolimnion of the lake.*

[e] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[f] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*Source: SEWRPC.*

## Table C-232

## GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF LOWER NEMAHBIN LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 271 acres |
| Direct Tributary Drainage Area | 595 acres |
| Shoreline | 3.30 miles |
| Depth: Maximum | 36 feet |
| Depth: Mean | 10.1 feet |
| Volume | 2,737 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 544 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

## Table C-233

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO LOWER NEMAHBIN LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975: Number | Existing 1975: Total Loading (pounds per year) | Existing 1975: Percent Distribution | Anticipated 2000[a]: Number | Anticipated 2000[a]: Total Loading (pounds per year) | Anticipated 2000[a]: Percent Distribution |
|---|---|---|---|---|---|---|
| Urban Land Cover (acres) | 226 | 36 | 7.4 | 492 | 88 | 9.8 |
| Land under Development—Construction Activities (acres) | – | – | – | 14 | 633 | 70.2 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 97 | 281 | 57.5 | 12 | 35 | 3.9 |
| Rural Land Cover (acres) | 369 | 36 | 7.3 | 89 | 9 | 1.0 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 271 | 135 | 27.8 | 271 | 136 | 15.1 |
| Total | – | 488[c] | 100.0 | – | 901[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

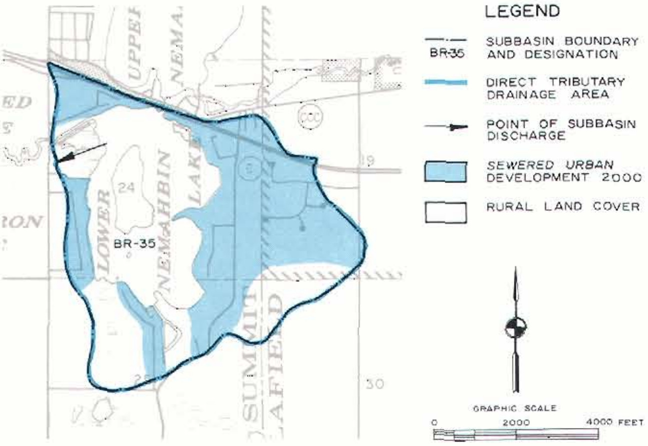
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 9,000 pounds per year or the year 2000 anticipated phosphorus load of 2,800 pounds per year contributed by the upstream drainage from Upper Nemahbin Lake.*

*Source: SEWRPC.*

*Map C-78*

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF LOWER NEMAHBIN LAKE: 2000**




Lower Nemahbin Lake has a direct tributary drainage area of about 595 acres. About 89 acres, or 15 percent of the drainage area, are planned to be in rural land cover, and 506 acres, or 85 percent, to be in urban land cover. Over the planning period an average of about 14 acres may be expected to be converted annually to urban land cover. It is estimated that in excess of 70 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices— including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Lower Nemahbin Lake which exceed the phosphorus level estimated to be necessary to maintain water quality suitable for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollutant loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-234, along with the associated costs and anticipated effectiveness. Measures to control phosphorus contributions include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

Even if nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-234 may include dredging, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Lower Nemahbin Lake requires that the level of nutrient input be reduced.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Lower Nemahbin Lake would entail a total capital cost of about $646,800, and an average annual operation and maintenace cost of about $6,600. The total 50-year present worth cost of these source control measures is $587,500, with an equivalent annual cost of $37,300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $27,100 for nutrient inactivation to $2,141,900 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $20,300 for nutrient inactivation to $1,600,000 for dredging.

Middle Genesee Lake

Middle Genesee Lake is a 102-acre lake located in the Town of Summit in Waukesha County. The lake is internally drained. Certain geomorphological characteristics of Middle Genesee Lake are set forth in Table C-235, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-79 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-79, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 45 privately owned onsite sewage disposal systems—4 of which were located

## Table C-234

### WATER QUALITY MANAGEMENT MEASURES FOR LOWER NEMAHBIN LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 70[j] |
| Minimum Rural Conservation Practices | Minimal | $ 400 | Minimal | $ 4,900 | $ 4,900 | Minimal | $ 300 | $ 300 | | |
| Construction Erosion Control Practices[d] | 646,800 | 5,600 | 485,500 | 88,300 | 573,800 | 30,800 | 5,600 | 36,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 600 | Minimal | 8,800 | 8,800 | Minimal | 600 | 600 | | |
| Total | 646,800 | 6,600 | 485,500 | 102,000 | 587,500 | 30,800 | 6,500 | 37,300 | | |
| Macrophyte Harvesting[e] | 46,600 | 6,500 | 34,800 | 102,500 | 137,300 | 2,200 | 6,500 | 8,700 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Nutrient Inactivation[f] | 27,100 | – | 20,300 | – | 20,300 | 1,300 | – | 1,300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,h] | 542,000 | – | 405,000 | – | 405,000 | 25,700 | – | 25,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[h,i] | 2,141,900 | – | 1,600,000 | – | 1,600,000 | 101,500 | – | 101,500 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Lower Nemahbin Lake drainage basin include a capital cost over the period of 1975-2000 of $1,368,000, an average annual operation and maintenance cost of $10,300, and a total 50-year present worth cost of $928,200.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Lower Nemahbin Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Lower Nemahbin Lake drainage basin include a capital cost over the period of 1980-2000 of $54,000, an average annual operation and maintenance cost of $1,000, and a total 50-year present worth cost of $63,100.*

[d] *Cost estimated to control erosion from the estimated 14 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 50 acres of Lower Nemahbin Lake subject to excessive macrophyte growth.*

[f] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

[i] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 10.1 feet.*

[j] *The reduction in the direct phosphorus load to Lower Nemahbin Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Bark River if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Lower Nemahbin Lake is to meet the water quality criteria for recreation and a warmwater fishery.*

*Source: SEWRPC.*

in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-236, all sources combined contribute about 140 pounds of phosphorus annually to Middle Genesee Lake. The major source of phosphorus in the lake watershed is rural land runoff. Also, as indicated in Tabe C-236, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.01 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Middle Genesee Lake which do not exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

## Table C-235

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF MIDDLE GENESEE LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 102 acres |
| Direct Tributary Drainage Area | 529 acres |
| Shoreline | 1.80 miles |
| Depth | |
| Maximum | 38 feet |
| Mean | 14.4 feet |
| Volume | 1,469 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 144 persons |
| General Existing Water Quality Conditions: | Generally good. Occasional low oxygen concentration in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Table C-236

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO MIDDLE LAKE GENESEE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 85 | 12 | 8.6 | 85 | 12 | 8.6 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | < 5 | 12 | 8.2 | < 5 | 12 | 8.2 |
| Rural Land Cover (acres) | 444 | 67 | 47.2 | 444 | 67 | 47.2 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 102 | 51 | 36.0 | 102 | 51 | 36.0 |
| Total | – | 142 | 100.0 | – | 142 | 100.0 |

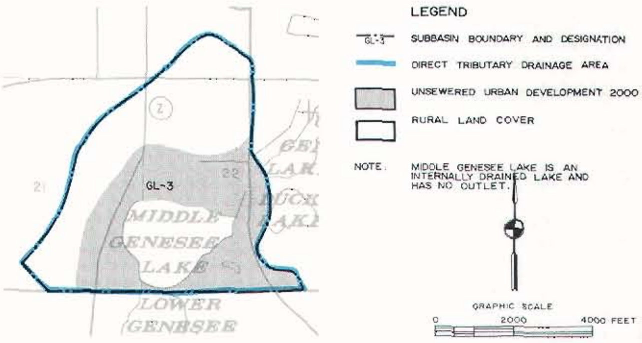
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Map C-79

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF MIDDLE GENESEE LAKE: 2000




Middle Genesee Lake has a direct tributary drainage area of about 529 acres. About 444 acres, or 84 percent of the drainage area, are planned to be in rural land cover, and 85 acres, or 16 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. It is recommended that several of these low cost measures be implemented to maintain lake water quality and to protect public health. These measures are set forth in Table C-237, along with the associated costs and anticipated effectiveness. Recommended measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

The sediments deposited in the lake may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-237 may include hypolimnetic aeration. The feasibility of this measure would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term

Table C-237

WATER QUALITY MANAGEMENT MEASURES FOR MIDDLE GENESEE LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | - | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 10 |
| Minimum Rural Conservation Practices | $ 100 | $ 800 | $ 100 | $ 9,500 | $ 9,600 | $ 100 | $ 600 | $ 700 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 2,100 | 2,100 | Minimal | 100 | 100 | | |
| Total | 100 | 900 | 100 | 11,600 | 11,700 | 100 | 700 | 800 | | |
| Macrophyte Harvesting[b] | 5,600 | 800 | 4,200 | 12,600 | 16,800 | 300 | 800 | 1,100 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 7,400 | 200 | 5,500 | 3,200 | 8,700 | 300 | 200 | 600 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion; reduce the release of nutrients from the sediment | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Middle Genesee Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Middle Genesee Lake drainage basin include a capital cost over the period of 1975-2000 of $18,000, an average annual operation and maintenance cost of $1,400, and a total 50-year present worth cost of $56,600.*

[b] *Cost estimated to harvest macrophytes from the 6 acres of Middle Genesee Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

*Source: SEWRPC*

maintenance of water quality in Middle Genesee Lake requires that the recommended level of nutrient input continue to be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Middle Genesee Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $900. The total 50-year present worth cost of these source control measures is $11,700, with an equivalent annual cost of $800. If, in addition, rehabilitation techniques are found necessary, the capital cost of hypolimnetic aeration would be $7,400. The total present worth cost of hypolimnetic aeration would be $8,700.

Moose Lake

Moose Lake is an 81-acre lake located in the Town of Merton in Waukesha County. The lake drains to the Oconomowoc River via Okauchee Lake. Certain geomorphological characteristics of Moose Lake are set forth in Table C-238, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-80 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-80, the majority of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 143 privately owned onsite sewage disposal systems—102 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-239, all direct sources combined contribute about 400 pounds of phosphorus annually to Moose Lake. The major source of phosphorus in the lake watershed is malfunctioning septic systems. Also, as indicated in Table C-239, urban land uses in the watershed are expected to increase by over 100 percent under year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to increase to about 800 pounds primarily as a result of contributions from construction activities. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.05 milligram per liter (mg/l) and 0.10 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Moose Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Table C-238

## GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF MOOSE LAKE

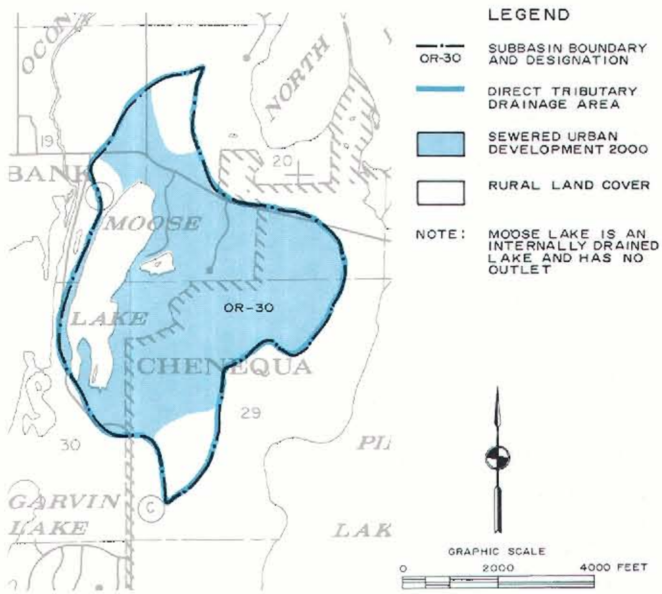
| Characteristic | Description |
|---|---|
| Surface Area | 81 acres |
| Direct Tributary Drainage Area | 553 acres |
| Shoreline | 2.30 miles |
| Depth | |
| Maximum | 61 feet |
| Mean | 28.7 feet |
| Volume | 2,325 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 502 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.51 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-80

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF MOOSE LAKE: 2000




Moose Lake has a direct tributary drainage area of about 553 acres. About 55 acres, or 10 percent of the drainage area, are planned to be in rural land cover, and 498 acres, or 90 percent, to be in urban land cover. Over the planning period an average of about 15 acres may be expected to be converted to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-239

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO MOOSE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 212 | 25 | 6.3 | 483 | 57 | 7.4 |
| Land under Development—Construction Activities (acres) | – | – | – | 15 | 656 | 84.7 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 102 | 295 | 74.6 | 5 | 15 | 1.9 |
| Rural Land Cover (acres) | 341 | 35 | 8.8 | 55 | 7 | 0.8 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 81 | 41 | 10.3 | 81 | 41 | 5.2 |
| Total | – | 396 | 100.0 | – | 776 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading to the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-240, along with the associated costs and anticipated effectiveness. Measures to control construction erosion contributions appear to be the most effective way to substantially control phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-240 may include nutrient inactivation, hypolimnetic aeration, and sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Moose Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Moose Lake would entail a total capital cost of about $693,100, and an average annual operation and maintenance cost of about $7,000. The total 50-year present worth cost of these source control measures is $627,400, with an equivalent annual cost of $39,900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,400 for nutrient inactivation to $162,000 for sediment covering. The total present worth costs of these

Table C-240

WATER QUALITY MANAGEMENT MEASURES FOR MOOSE LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | — | — | — | — | — | — | — | — | Protect public health and drinking water supplies; reduce nutrient concentrations | — |
| Septic Tank System Management[c] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 80 |
| Minimum Rural Conservation Practices | $ < 100 | $ 400 | $ 0 | $ 4,400 | $ 4,400 | $ < 100 | $ 300 | $ 400 | | |
| Construction Erosion Control Practices[d] | 693,000 | 6,000 | 520,110 | 94,600 | 614,700 | 33,000 | 6,000 | 39,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 600 | Minimal | 8,300 | 8,300 | Minimal | 500 | 500 | | |
| Total | 693,100 | 7,000 | 520,100 | 107,300 | 627,400 | 33,100 | 6,800 | 39,900 | | |
| Macrophyte Harvesting[e] | 3,700 | 500 | 2,800 | 7,900 | 10,700 | 200 | 500 | 700 | *Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential* | *Minimal additional reduction* |
| Hypolimnetic Aeration[f] | 8,800 | 200 | 6,600 | 3,200 | 9,800 | 400 | 200 | 600 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 4,400 to 8,100 | — | 3,300 to 6,100 | — | 3,300 to 6,100 | 200 to 400 | — | 200 to 400 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 162,000 | — | 121,100 | — | 121,100 | 7,700 | — | 7,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Moose Lake drainage basin include a capital cost over the period of 1975-2000 of $1,384,000, an average annual operation and maintenance cost of $10,400, and a total 50-year present worth cost of $939,000.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Moose Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Moose Lake drainage basin include a capital cost over the period of 1975-2000 of $22,500, an average annual operation and maintenance cost of $400, and a total 50-year present worth cost of $26,600.*

[d] *Cost estimated to control erosion from the estimated 14.6 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 4 acres of Moose Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material. Actual costs may be higher depending on lake physiography.*

[i] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

lake rehabilitation techniques would range from $3,300 for nutrient inactivation to $121,100 for sediment covering.

Nagawicka Lake

Nagawicka Lake is a 957-acre lake located in the City of Delafield and the Village of Nashotah in Waukesha County. The lake is fed by and drains to the Bark River. Certain geomorphological characteristics of Nagawicka Lake are set forth in Table C-241, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[20] Map C-81 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-81, the majority of the existing urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 690 privately owned onsite sewage disposal systems—279 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-242, all direct tributary sources combined contribute about 5,600 pounds of phosphorus annually to Nagawicka Lake. The major source of phosphorus in the lake watershed is livestock operations. An additional 5,700 pounds of phosphorus enter the lake annually with the inflow of the Bark River. Also, as indicated in Table C-242, urban land uses in the watershed are expected to increase by about 25 percent under planned year 2000 land cover conditions, with annual direct total phosphorus loadings to the lake expected to be increased to about 7,300 pounds as a result of the increase in construction activity. Loadings from livestock operations are expected to remain the primary direct source of phosphorus to the lake under anticipated year 2000 conditions. By year 2000, Bark River phosphorus loads to Nagawicka Lake are expected to be reduced to 1,400 pounds primarily as a result of the abandonment of the Hartland sewage treatment facility. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.08 milligram per liter (mg/l) and 0.06 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Nagawicka Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

[20]*Report on Nagawicka Lake, National Eutrophication Survey, U.S. Environmental Protection Agency, 1975.*

**Table C-241**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF NAGAWICKA LAKE**

| Characteristic | Description |
|---|---|
| Surface Area | 957 acres |
| Direct Tributary Drainage Area | 5,352 acres |
| Shoreline | 8.60 miles |
| Depth | |
| Maximum | 90 feet |
| Mean | 48 feet |
| Volume | 45,936 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 2,325 persons |
| General Existing Water Quality Conditions: | Severe algae blooms; excessive macrophyte growth; high nutrient concentrations; lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.37 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

**Table C-242**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO NAGAWICKA LAKE: 1975 and 2000**

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,626 | 363 | 6.5 | 2,060 | 460 | 6.3 |
| Land under Development—Construction Activities (acres) | – | – | – | 49 | 2,199 | 30.1 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 279 | 808 | 14.5 | 106 | 307 | 4.2 |
| Rural Land Cover (acres) | 3,726 | 359 | 6.4 | 3,243 | 307 | 4.2 |
| Livestock Operations (animal units) | 540 | 3,564 | 64.0 | 340 | 3,564 | 48.7 |
| Atmospheric Contribution (acres of receiving surface water) | 957 | 479 | 8.6 | 957 | 479 | 6.5 |
| Total | – | 5,573[c] | 100.0 | – | 7,316[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

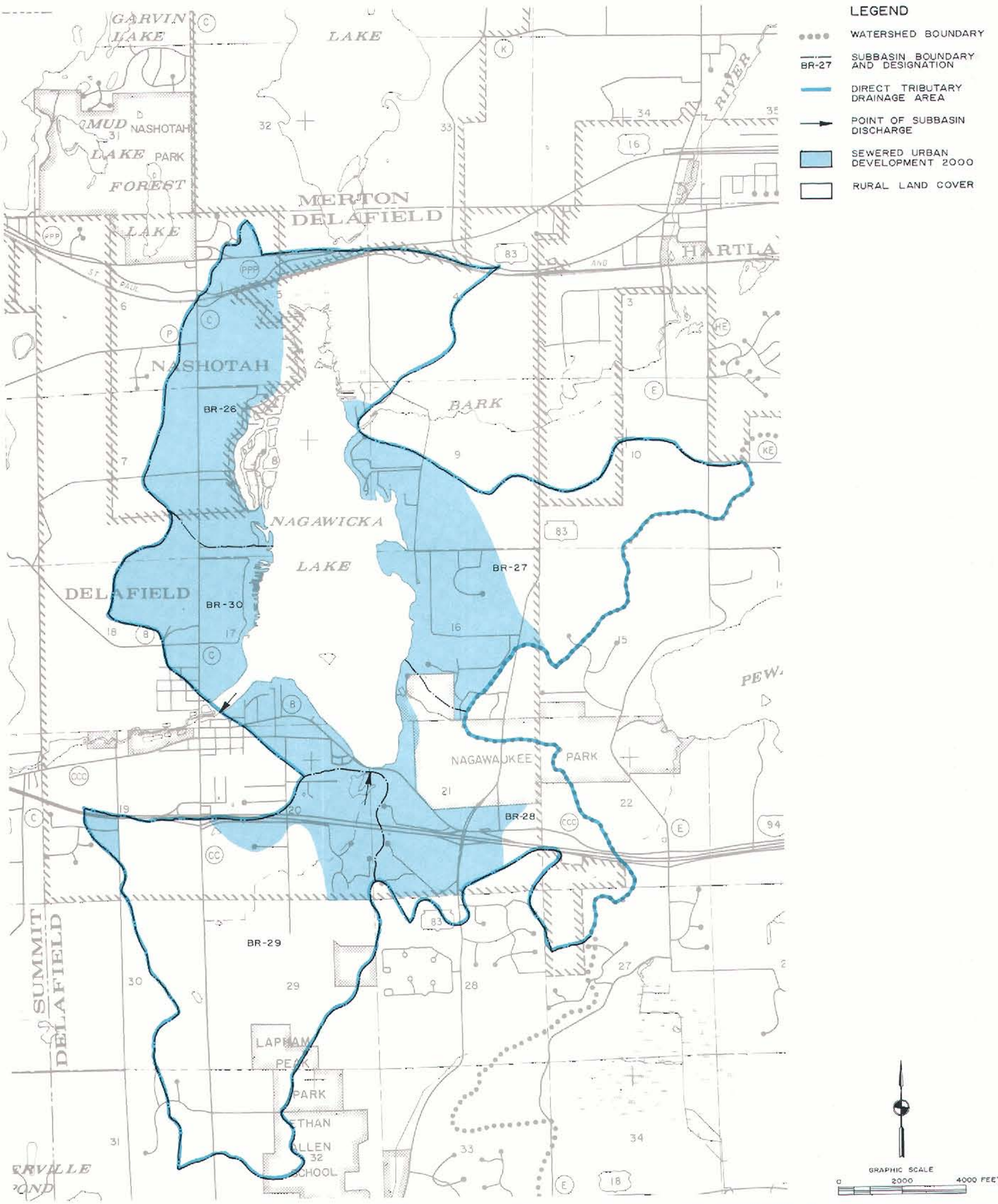
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated upstream load of 5,700 pounds per year or the year 2000 anticipated phosphorus load of 1,400 pounds per year contributed by the upstream drainage from the Bark River.*

*Source: SEWRPC.*

Map C-81

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF NAGAWICKA LAKE: 2000**




Nagawicka Lake has a direct tributary drainage area of about 5,352 acres. About 3,243 acres, or 61 percent of the drainage area, are planned to be in rural land cover, and 2,109 acres, or 39 percent, to be in urban land cover. Over the planning period an average of about 49 acres may be expected to be converted annually to urban land cover. It is estimated that a 70 percent reduction in point source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading to the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-243, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte

**Table C-243**

**WATER QUALITY MANAGEMENT MEASURES FOR NAGAWICKA LAKE IN WAUKESHA COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health | 85[j] |
| Livestock Waste Control | $ 47,500 | $ 4,000 | $ 35,500 | $ 47,700 | $ 83,200 | $ 2,300 | $ 3,000 | $ 5,300 | | |
| Minimum Rural Conservation Practices | 700 | 6,100 | 500 | 74,400 | 74,900 | 100 | 4,700 | 4,800 | | |
| Construction Erosion Control Practices[d] | 2,263,800 | 19,600 | 1,699,100 | 308,900 | 2,008,000 | 107,800 | 19,600 | 127,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 3,000 | 0 | 45,000 | 45,000 | 0 | 2,900 | 2,900 | | |
| Total Diffuse Source Control | 2,312,000 | 32,700 | 1,735,100 | 476,000 | 2,211,100 | 110,200 | 30,200 | 140,400 | | |
| Macrophyte Harvesting[e] | 44,700 | 6,200 | 33,400 | 97,700 | 131,100 | 2,100 | 6,200 | 8,300 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 97,400 | 2,400 | 72,800 | 37,800 | 146,600 | 4,600 | 2,400 | 9,300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 48,700 to 95,700 | – | 36,400 to 71,500 | – | 36,400 to 71,500 | 2,300 to 4,500 | – | 2,300 to 4,500 | Accelerate lake improvement; prevent release of nutrient from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 1,914,000 | – | 1,430,300 | – | 1,430,300 | 90,700 | – | 90,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area presented later in this chapter. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Nagawicka Lake drainage basin include a capital cost over the period of 1975-2000 of $10,012,000, an average annual operation and maintenance cost of $96,800, and a total 50-year present worth cost of $7,136,000.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Nagawicka Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Nagawicka Lake drainage basin include a capital cost over the period of 1975-2000 of $477,000, an average annual operation and maintenance cost of $5,800, and a total 50-year present worth cost of $468,000.*

[d] *Cost estimated to control erosion from the estimated 49 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the approximately 50 acres of Nagawicka Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

[j] *The reduction in the direct phosphorus load to Nagawicka Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Bark River if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Nagawicka Lake is to meet the water quality criteria for recreation and a warmwater fishery.*

*Source: SEWRPC.*

growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-243 may include sediment covering, hypolimnetic aeration, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control temporarily the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Nagawicka Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above listed nonpoint source pollution control measures to control the nutrient inputs to Nagawicka Lake would entail a total capital cost of about $2,312,000, and an average annual operation and maintenance cost of about $32,700. The total 50-year present worth cost of these nonpoint source control measures is $2,211,100, with an equivalent annual cost of $140,400. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $48,700 for nutrient inactivation to $1,914,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $36,400 for nutrient inactivation to $1,430,300 for sediment covering.

North Lake

North Lake is a 437-acre lake located in the Town of Merton in Waukesha County. The lake drains to the Oconomowoc River. Certain geomorphological characteristics of North Lake are set forth in Table C-244, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[21] Map C-82 presents a graphic summary of the proposed year 2000 land cover in the direct tributary lake watershed. As shown on Map C-82, a large portion of the urban land in the direct tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 232 privately owned onsite sewage disposal systems—90 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake direct tributary watershed area.

Table C-244

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF NORTH LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 437 acres |
| Direct Tributary Drainage Area | 1,648 acres |
| Shoreline | 5.30 miles |
| Depth | |
| Maximum | 70 feet |
| Mean | 40 feet |
| Volume | 17,480 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 814 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; high nutrient concentrations; lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.51 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

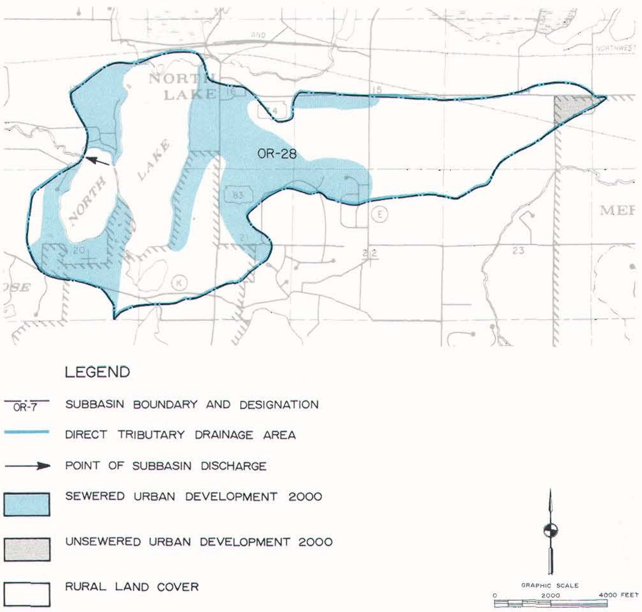
*Source: SEWRPC.*

As indicated in Table C-245, all direct tributary sources combined contribute about 1,600 pounds of phosphorus annually to North Lake. An additional 3,900 pounds enter the lake annually as inflow from the Oconomowoc River. Therefore, about 5,500 pounds of total phosphorus per year are estimated to enter North Lake under existing conditions. These pollutant loads were estimated based on data developed during detailed field studies conducted during a period of below-average precipitation and general pollutant source loading estimates for the lake watershed for conditions during an average or typical year. Also, as indicated in Table C-245, urban land uses in the watershed are expected to increase by about 80 percent under planned year 2000 conditions with annual direct tributary phosphorus loads expected to increase as a result of construction activity. However, Oconomowoc River annual total phosphorus loads are expected to decrease to about 2,300 pounds as a result of improved conditions upstream of North Lake. The expected year 2000 annual total phosphorus load to North Lake from direct tributary and upstream loads is 4,670 pounds. The observed total phosphorus concentration during study year 1976 spring overturn was 0.04 milligram per liter (mg/l). The expected year 2000 steady state spring total phosphorus concentration is 0.03 mg/l. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be

[21] *See separately published SEWRPC Community Assistance Planning Report on Water Quality Management for North Lake, Waukesha County, for a more detailed discussion of the findings and recommendations of the detailed field study.*

Map C-82

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF NORTH LAKE: 2000




North Lake has a direct tributary drainage area of about 1,648 acres. About 824 acres, or 50 percent of the drainage area, are planned to be in rural land cover, and 824 acres, or 50 percent, to be in urban land cover. Over the planning period an average of about 22 acres may be expected to be converted annually to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

C-245

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO NORTH LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 446 | 68 | 4.3 | 802 | 94 | 4.0 |
| Land under Development—Construction Activities (acres) | – | – | – | 22 | 969 | 40.8 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 90 | 261 | 16.5 | 29 | 84 | 3.5 |
| Rural Land Cover (acres) | 1,202 | 113 | 7.1 | 824 | 83 | 3.5 |
| Livestock Operations (animal units) | 140 | 924 | 58.3 | 140 | 924 | 39.0 |
| Atmospheric Contribution (acres of receiving surface water) | 437 | 219 | 13.8 | 437 | 219 | 9.2 |
| Total | – | 1,585[c] | 100.0 | – | 2,373[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 3,900 pounds per year or the year 2000 anticipated phosphorus load of 2,300 pounds per year contributed by the drainage from the upstream Oconomowoc River watershed area.*

*Source: SEWRPC.*

expected to result in total phosphorus concentrations in North Lake which exceed the recommended level for recreational use and for the maintenance of a warm-water fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-246, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. When this problem is confirmed through further local study, the specific lake restoration or rehabilitation procedures which are appropriate should be identified for application after implementation of the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-246, may include the construction of a permanent control structure at the outlet of "Funk's Millpond" on the Oconomowoc River, upstream of the lake. This alternative would serve two purposes: it would act as a settling basin for sediment and nutrients; and retain and control release of spring runoff water which may reduce slightly the spring flooding problems in low-lying areas, and thereby reduce slightly the pollutant loads from septic systems improperly located in the floodplain. It has also been suggested by members of the North Lake Environmental Protection Association that an outlet control structure be constructed for North Lake to help abate flooding problems which occur during periods of wet weather. The feasibility of these measures would have to be assessed in a systems level comprehensive watershed study and in subsequent preliminary engineering studies if appropriate. It should be emphasized, however, that the long-term maintenance of water quality in North Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to North Lake would entail a total capital cost of about $1,028,900, and an average annual operation and maintenance cost of about $12,700. The total 50-year present worth cost of these source control measures is $960,200,

## Table C-246

### WATER QUALITY MANAGEMENT MEASURES FOR NORTH LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | — | — | — | — | — | — | — | — | Protect public health and drinking water supplies; reduce nutrient concentrations | — |
| Septic Tank System Management[c] | — | — | — | — | — | — | — | — | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 12,300 | $ 1,100 | $ 9,200 | $ 12,400 | $ 21,600 | $ 1,600 | $ 800 | $ 2,400 | | |
| Minimum Rural Conservation Practices | 200 | 1,800 | 200 | 22,100 | 22,300 | 100 | 1,400 | 1,400 | | |
| Construction Erosion Control Practices[d] | 1,016,400 | 8,800 | 762,900 | 138,700 | 901,600 | 48,400 | 8,800 | 57,200 | | 80 |
| Low Cost Urban Land Management Practices | Minimal | 1,000 | Minimal | 14,700 | 14,700 | Minimal | 900 | 900 | | |
| Total | 1,028,900 | 12,700 | 772,300 | 187,900 | 960,200 | 50,100 | 11,900 | 62,000 | | |
| Inlet Control Structure | Cost based on design | | Cost based on design | | | Cost based on design | | | Removal of sediments and nutrients. Control of flooding | Could be significant |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the North Lake drainage basin include a capital cost over the period of 1975-2000 of $1,712,000, an average annual operation and maintenance cost of $12,800, and a total 50-year present worth cost of $1,161,600.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of North Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the North Lake drainage basin include a capital cost over the period of 1975-2000 of $130,500, an average annual operation and maintenance cost of $1,400, and a total 50-year present worth cost of $119,900.*

[d] *Cost estimated to control erosion from the estimated 21.5 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*Source: SEWRPC*

with an equivalent annual cost of $62,000. If, in addition, the construction of a control structure at the inlet and/or outlet to North Lake is proven to be feasible, the cost of said structure costs would then be determined by the specific designs selected.

Oconomowoc Lake

Oconomowoc Lake is a 767-acre lake located in the Town of Summit in Waukesha County. The lake drains to the Oconomowoc River. Certain geomorphological characteristics of Oconomowoc Lake are set forth in Table C-247, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[22,23] Map C-83 presents a graphic summary of the proposed year

[22]*See separately published SEWRPC Community Assistance Planning Report on Water Quality Management for Oconomowoc Lake, Waukesha County, for a more detailed discussion of the findings and recommendations of the detailed field study.*

[23]*Report on Oconomowoc Lake, National Eutrophication Survey, U.S. Environmental Protection Agency, 1975.*

## Table C-247

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF OCONOMOWOC LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 767 acres |
| Direct Tributary Drainage Area | 1,934 acres |
| Shoreline | 7.0 miles |
| Depth | |
| Maximum | 60 feet |
| Mean | 32 feet |
| Volume | 24,697 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 797 persons |
| General Existing Water Quality Conditions: | Nuisance macrophyte growth; high nutrient concentrations; lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

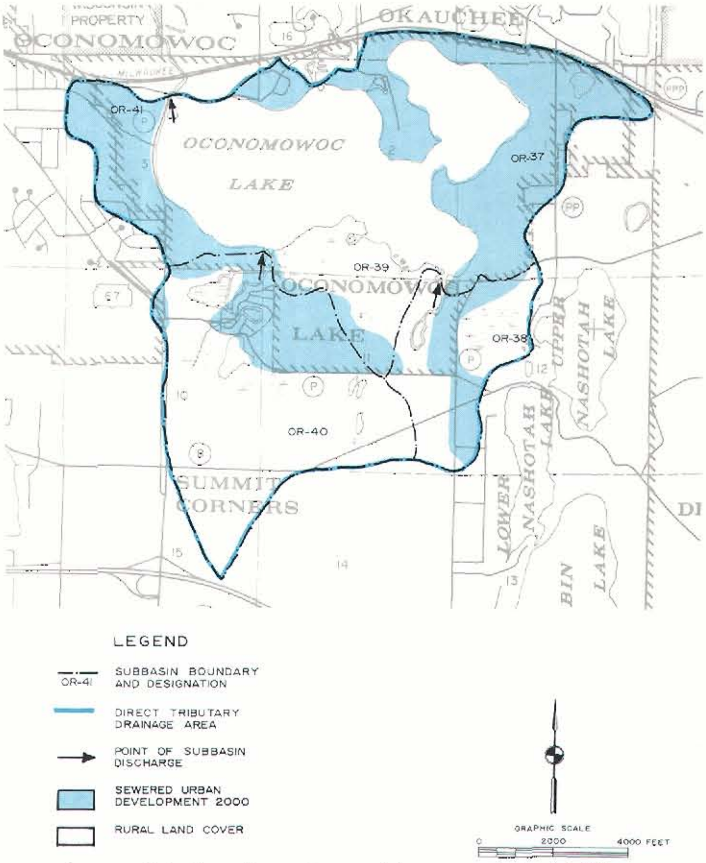
2000 in the direct tributary lake watershed. As shown on Map C-83, all significant urban land areas in the direct tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 181 privately owned onsite sewage disposal systems—86 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. The sanitary sewer service area is proposed to be extended within the direct lake tributary watershed under planned year 2000 conditions.

As indicated in Table C-248, all direct tributary sources combined contribute about 1,700 pounds of total phosphorus annually to Oconomowoc Lake during an average year of precipitation. An additional estimated 5,300 pounds of total phosphorus enters the lake annually as discharge from Okauchee Lake via the Oconomowoc River. Therefore, about 7,000 pounds of total phosphorus are estimated to enter Oconomowoc Lake under existing conditions. These pollutant loads were estimated based on data developed during detailed field studies conducted during a period of below average precipitation and general pollutant source loading estimates for the lake watershed for average or typical year conditions. Also, as indicated in Table C-248, urban land uses in the watershed are expected to increase by about 85 percent under planned year 2000 land cover conditions, with annual direct phosphorus loadings to the lake expected to be reduced to about 1,460 pounds as a result of the provision of sanitary sewerage facilities. The annual phosphorus load from Okauchee Lake is expected to be reduced to about 2,900 pounds as a result of lake watershed management recommended for that tributary lake. The observed total phosphorus concentration during study year 1976 spring overturn was 0.04 milligram per liter (mg/l). The expected year 2000 steady state spring phosphorus concentration is 0.03 mg/l. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Oconomowoc Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-249, along with the associated costs and anticipated effectiveness. Measures to control construction activity contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic oil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

Map C-83

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF OCONOMOWOC LAKE: 2000




Oconomowoc Lake has a direct tributary drainage area of about 1,934 acres. About 967 acres, or 50 percent of the drainage area, are planned to be in rural land cover, and 967 acres, or 50 percent, to be in urban land cover. Over the planning period an average of about 19 acres may be expected to be converted annually to urban land cover. A combination of minimum rural land management practices—including especially the proper management of agricultural cropping activities—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake watershed drainage area.

*Source: SEWRPC.*

Table C-248

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO OCONOMOWOC LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 512 | 93 | 5.5 | 948 | 111 | 7.6 |
| Land under Development—Construction Activities (acres) | 19 | 850 | 49.8 | 19 | 850 | 58.2 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 86 | 248 | 14.5 | 9 | 26 | 1.8 |
| Rural Land Cover (acres) | 1,403 | 132 | 7.7 | 967 | 90 | 6.2 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 767 | 383 | 22.5 | 767 | 383 | 26.2 |
| Total | – | 1,706[c] | 100.0 | – | 1,459[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 5,300 pounds per year or the year 2000 anticipated phosphorus load of 2,900 pounds per year contributed by the upstream drainage area of the Oconomowoc River through the Okauchee Lake outlet.*

*Source: SEWRPC.*

Table C-249

WATER QUALITY MANAGEMENT MEASURES FOR OCONOMOWOC LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | 60[h] |
| Minimum Rural Conservation Practices | $ 200 | $ 2,100 | $ 200 | $ 25,300 | $ 25,500 | $ 100 | $ 1,600 | $ 1,700 | | |
| Construction Erosion Control Practices[d] | 877,800 | 7,600 | 658,800 | 119,800 | 778,600 | 41,800 | 7,600 | 49,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,200 | Minimal | 17,800 | 17,800 | Minimal | 1,100 | 1,100 | | |
| Total | 878,000 | 10,900 | 659,000 | 162,900 | 821,900 | 41,900 | 10,300 | 52,000 | | |
| Macrophyte Harvesting[e] | 39,100 | 5,500 | 29,200 | 86,700 | 115,900 | 1,900 | 5,500 | 7,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Sediment Covering[f,g] | 1,534,000 | – | 1,146,400 | – | 1,146,400 | 72,700 | – | 72,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Costs represent the estimated cost of wastewater treatment and trunk sewer facilities for the Bristol-George Lake Sewer Service area prorated based upon the population of the lake watershed to the total sewered population of the service area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Oconomowoc Lake drainage basin include a capital cost over the period of 1975-2000 of $1,096,000, an average annual operation and maintenance cost of $10,300, and a total 50-year present worth cost of $775,800.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Oconomowoc Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Oconomowoc Lake drainage basin include a capital cost over the period of 1975-2000 of $40,500, an average annual operation and maintenance cost of $1,000, and a total 50-year present worth cost of $56,200.*

[d] *Cost estimated to control erosion from the estimated 18.9 acres of land estimated to be annually undergoing construction activity in the Oconomowoc Lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 42 acres of Oconomowoc Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[g] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

[h] *The reduction in the direct phosphorus load to Oconomowoc Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Oconomowoc River if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Oconomowoc Lake is to meet the water quality criteria for recreation and a warmwater fishery.*

*Source: SEWRPC.*

Once nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom will continue to provide suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. When this problem is confirmed through further local study, the specific lake restoration or rehabilitation procedures which are appropriate should be identified for application, after implementation of the above-mentioned point and nonpoint source controls. In addition to continued weed harvesting, alternative restoration measures as set forth in Table C-249 may include sediment covering. Chemical treatment to control algae can be used if necessary, but only as a temporary solution to the problem. The feasibility of these measures would have to be assessed in a preliminary engineering study. It should be emphasized, however, that the long-term maintenance of water quality in Oconomowoc Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Oconomowoc Lake would entail a total capital cost of about $878,000, and an average annual operation and maintenance cost of about $10,900. The total 50-year present worth cost of these source control measures is $821,900 with an equivalent annual cost of $52,200. If, in addition, rehabilitation techniques are found necessary, the capital cost of sediment covering would be

$1,534,000. The total present worth cost of sediment covering would be $1,146,400.

Okauchee Lake

Okauchee Lake is a 1,187-acre lake located in the Towns of Oconomowoc and Merton in Waukesha County. The lake drains to the Oconomowoc River. Certain geomorphological characteristics of Okauchee Lake are set forth in Table C-250, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[24] Map C-84 presents a graphic summary of the proposed year 2000 land cover in the lake watershed utilized in the areawide water quality plan. The delineated tributary drainage area should be refined in a more detailed local lake study. As shown on Map C-84, the majority of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 1,160 privately owned onsite sewage disposal systems—650 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-251, all direct sources combined contribute about 6,900 pounds of phosphorus annually to Okauchee Lake. The major source of phosphorus in the lake watershed in livestock operations. An additional 2,900 pounds of phosphorus annually enter the lake from upstream drainage from the Oconomowoc River and from Moose Lake. Also, as indicated in Table C-251, urban land uses in the watershed are expected to increase by about 45 percent under year 2000 conditions. Total phosphorus loads will not change greatly since the reduction in phosphorus loads from septic tank systems due to the provision of sanitary sewer service area will be offset by the increased phosphorus runoff from construction activity. Upstream phosphorus loads are, however, expected to decrease to about 1,500 pounds per year under year 2000 conditions as a result of upstream management practices. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as measured for the present and estimated from phosphorus loadings and lake and drainage basin characteristics for year 2000, are 0.06 milligram per liter (mg/l) and 0.5 mg/l, respectively.

[24]*Report on Okauchee Lake, National Eutrophication Survey, U.S. Environmental Protection Agency, 1975.*

Table C-250

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF OKAUCHEE LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 1,187 acres |
| Direct Tributary Drainage Area | 4,757 acres |
| Shoreline | 15.0 miles |
| Depth | |
| Maximum | 90 feet |
| Mean | 27.5 feet |
| Volume | 32,642 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 3,296 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; deoxygenated hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-251

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO OKAUCHEE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 1,324 | 264 | 3.8 | 1,926 | 384 | 5.4 |
| Land under Development–Construction Activities (acres) | – | – | – | 40 | 1,778 | 25.0 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 650 | 1,882 | 27.2 | 81 | 234 | 3.3 |
| Rural Land Cover (acres) | 3,433 | 307 | 4.4 | 2,791 | 240 | 3.4 |
| Livestock Operations (animal units) | 588 | 3,881 | 56.0 | 588 | 3,881 | 54.5 |
| Atmospheric Contribution (acres of receiving surface water) | 1,187 | 594 | 8.6 | 1,187 | 594 | 8.4 |
| Total | – | 6,928[c] | 100.0 | – | 7,111[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

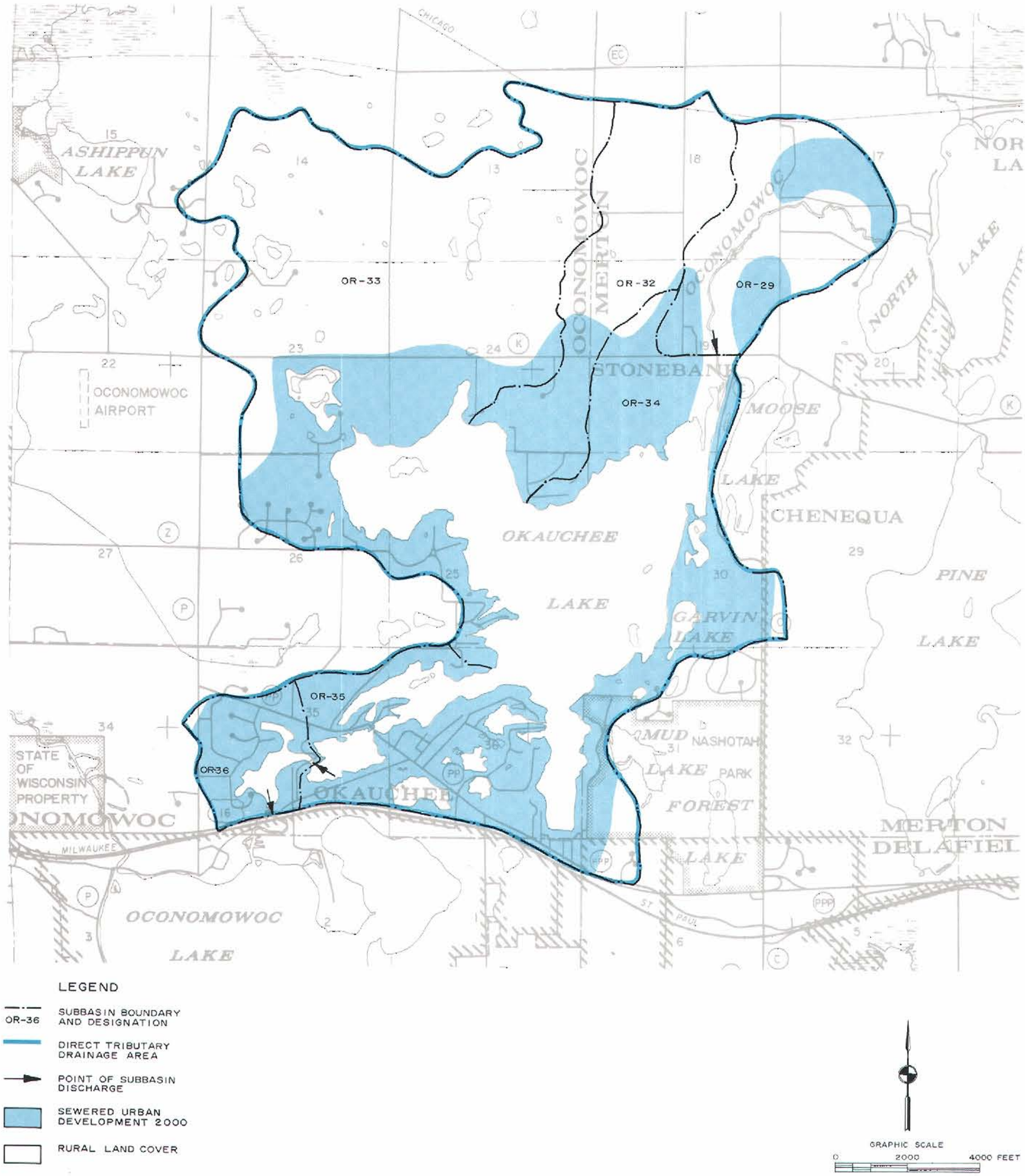
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 2,900 pounds per year or the year 2000 anticipated phosphorus load of 1,500 pounds per year contributed by the upstream drainage from the Oconomowoc River or from Moose Lake.*

*Source: SEWRPC.*

Map C-84

**PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF OKAUCHEE LAKE: 2000**




Okauchee Lake has a direct tributary drainage area of about 4,757 acres. About 2,791 acres, or 59 percent of the drainage area, are planned to be in rural land cover, and 1,966 acres, or 41 percent, to be in urban land cover. Over the planning period about 40 acres of the direct tributary watershed area are expected to be annually converted to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warm-water fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Okauchee Lake which exceed the recommended level for recreational use and for the maintenance of a warm-water fishery.

The measures available controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-252, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved management of the remaining septic tank systems, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

**Table C-252**

**WATER QUALITY MANAGEMENT MEASURES FOR OKAUCHEE LAKE IN WAUKESHA COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 51,700 | $ 4,400 | $ 38,700 | $ 51,900 | $ 90,600 | $ 2,500 | $ 3,300 | $ 5,800 | | |
| Minimum Rural Conservation Practices | 600 | 5,500 | 500 | 66,600 | 67,100 | 100 | 4,200 | 4,300 | | |
| Construction Erosion Control Practices[d] | 1,824,900 | 15,800 | 1,369,700 | 249,000 | 1,618,700 | 86,900 | 15,800 | 102,700 | | 60 |
| Low Cost Urban Land Management Practices | Minimal | 2,700 | Minimal | 39,500 | 39,500 | Minimal | 2,500 | 2,500 | | |
| Total | 1,877,200 | 28,400 | 1,408,900 | 407,000 | 1,815,900 | 89,500 | 25,800 | 115,300 | | |
| Macrophyte Harvesting[e] | 36,300 | 5,100 | 27,100 | 80,400 | 107,500 | 1,700 | 5,100 | 6,800 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 100,000 | 2,500 | 74,700 | 39,400 | 114,100 | 4,700 | 2,500 | 7,200 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 50,000 to 118,700 | – | 37,400 to 88,700 | – | 37,400 to 88,700 | 2,400 to 5,600 | – | 2,400 to 5,600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 2,374,000 | – | 1,774,100 | – | 1,774,100 | 112,500 | – | 112,500 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Okauchee Lake drainage basin include a capital cost over the period of 1975-2000 of $5,552,000, an average annual operation and maintenance cost of $41,600, and a total 50-year present worth cost of $3,767,000.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Okauchee Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Okauchee Lake drainage basin include a capital cost over the period of 1975-2000 of $364,500, an average annual operation and maintenance cost of $4,600, and a total 50-year present worth cost of $363,900.*

[d] *Cost estimated to control erosion from the estimated 39.5 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 39 acres of Okauchee Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local area and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-252 may include nutrient inactivation, hypolimnetic aeration, or sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Okauchee Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Okauchee Lake would entail a total capital cost of about $1,877,200, and an average annual operation and maintenance cost of about $28,400. The total 50-year present worth cost of these source control measures is $1,815,900, with an equivalent annual cost of $115,300. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $50,000 for nutrient inactivation to $2,374,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $37,400 for nutrient inactivation to $1,774,100 for sediment covering.

Table C-253

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PIKE LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 522 acres |
| Direct Tributary Drainage Area | 2,455 acres |
| Shoreline | 3.80 miles |
| Depth | |
| Maximum | 45 feet |
| Mean | 13.3 feet |
| Volume | 6,942 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,880 persons |
| General Existing Water Quality Conditions: | Generally good; occasional algae blooms; some macrophyte growth; low dissolved oxygen concentrations in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.3 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Pike Lake

Pike Lake is a 522-acre lake located in the Town of Hartford in Washington County. The lake drains to the Rubicon River. Certain geomorphological characteristics of Pike Lake are set forth in Table C-253, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[25] Map C-85 presents a graphic summary of the propsed year 2000 land cover in the direct tributary lake watershed. As shown on Map C-85, only a small portion of the direct tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 239 privately owned onsite sewage disposal systems—102 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake direct tributary watershed area.[26]

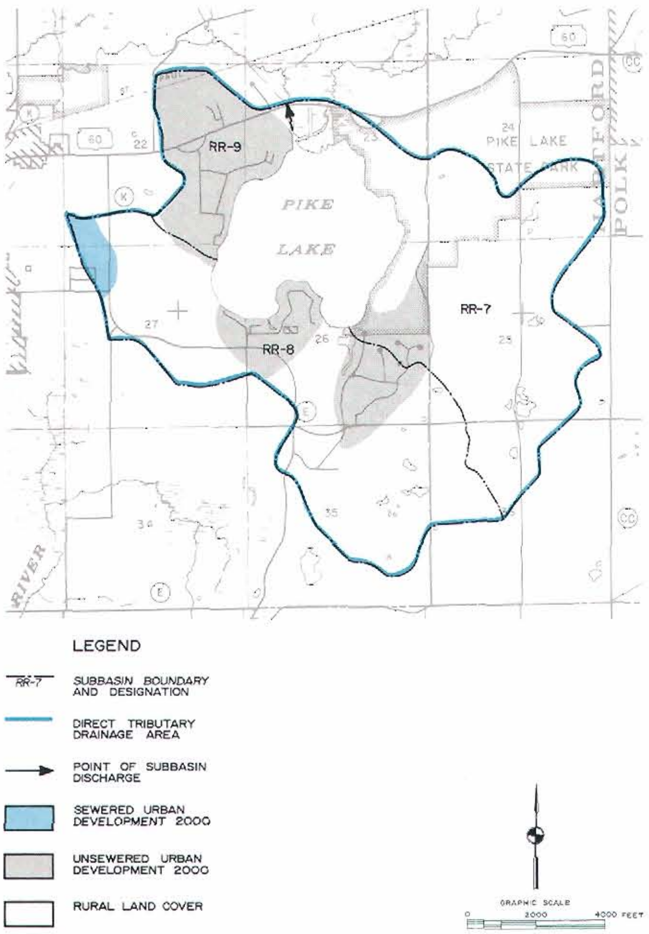
As indicated in Table C-254, based on Department of Natural Resources field study results, water quality simulation analyses, and phosphorus loading estimates, all direct tributary sources combined contribute about 3,900 pounds of phosphorus annually to Pike Lake during an average year of precipitation. In addition, it is estimated that approximately 10 percent of the upstream load of 4,000 pounds, or about 400 pounds of total phosphorus, enter Pike Lake from the upstream indirect tributary watershed area. The remaining 90 percent is assumed to bypass Pike Lake and continue to flow downstream via the Rubicon River. Therefore, about 4,300 pounds of total phosphorus per year are estimated to enter Pike Lake under existing conditions. These pollutant loads were estimated based on data developed during detailed field studies—conducted during a period of

[25]*See separately published SEWRPC Community Assistance Planning Report on Water Quality Management for Pike Lake, Washington County, for a more detailed discussion of the findings and recommendations of the detailed field study.*

[26]*The provision of sanitary sewer service to the lake watershed was proposed in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin. However, field studies conducted by the Department of Natural Resources have demonstrated that sanitary sewer service is probably not required if proper septic tank system maintenance is assured. As presented in the point source element discussions in Chapter 4 of this volume sanitary sewer service is no longer recommended for the Pike Lake Watershed, except for a small portion of the watershed located within the proposed Hartford sanitary sewer service area.*

Map C-85

## PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PIKE LAKE: 2000




Pike Lake has a direct tributary drainage area of about 2,455 acres. About 2,120 acres, or 86 percent of the drainage area, are planned to be in rural land cover, and 335 acres, or 14 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-254

## ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PIKE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 335 | 59 | 1.5 | 335 | 59 | 1.5 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 102 | 295 | 7.6 | 102 | 295 | 7.6 |
| Rural Land Cover (acres) | 2,120 | 207 | 5.4 | 2,120 | 207 | 5.4 |
| Livestock Operations (animal units) | 462 | 3,049 | 78.8 | 462 | 3,049 | 78.8 |
| Atmospheric Contribution (acres of receiving surface water) | 522 | 261 | 6.7 | 522 | 261 | 6.7 |
| Total | – | 3,871[c] | 100.0 | – | 3,871[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated and the year 2000 anticipated phosphorus load of 400 pounds per year contributed by upstream drainage of the Rubicon River.*

*Source: SEWRPC.*

below average precipitation—and general pollutant source loading estimates for the lake watershed for average or typical year conditions. Also, as indicated in Table C-254, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during study year 1976 spring overturn was about 0.03 milligram per liter (mg/l), which is representative of a dry year condition. The water quality simulation analyses indicated that, during a year of average precipitation, the spring phosphorus concentration would approximate 0.05 mg/l under both existing and anticipated year 2000 conditions. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Pike Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery in the year 2000.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-255, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands. Although the provision of sanitary sewers is not currently recommended for Pike Lake, based on data from the Commissions inland lake water quality study conducted for Pike Lake, it is recommended in the upper Rock River Subregional area discussion of the point source plan element discussed in Chapter IV of this volume that a local facilities planning program for septic tank system management be undertaken to locate and correct those systems which are malfunctioning.

Table C-255

WATER QUALITY MANAGEMENT MEASURES FOR PIKE LAKE IN WASHINGTON COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Management[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential; protect public health and drinking water supplies | |
| Livestock Waste Control | $ 40,700 | $ 3,500 | $ 30,400 | $ 40,800 | $ 71,200 | $ 1,900 | $ 2,600 | $ 4,500 | | |
| Minimum Rural Conservation Practices and Streambank Protection | 600 | 3,800 | 400 | 46,800 | 47,200 | 100 | 3,000 | 3,100 | | |
| Low Cost Urban Land Management Practices | Minimal | 400 | Minimal | 6,400 | 6,400 | Minimal | 400 | 400 | | |
| Total | 41,300 | 7,700 | 30,800 | 94,000 | 124,800 | 2,000 | 6,000 | 8,000 | | 80 |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Pike Lake. However, because spetic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Pike Lake drainage basin include a capital cost over the period of 1975-2000 of $459,000, an average annual operation and maintenance cost of $8,200, and a total 50-year present worth cost of $537,100.*

*Source: SEWRPC*

Based upon the results of the Commission inland lake study, existing water quality conditions in Pike Lake do not warrant the implementation of inlake rehabilitation measures at this time. Control at the source to eliminate or substantially reduce the pollutant loading of nutrients, sediment, and pathogenic organisms should adequately maintain and enhance the surface and groundwater quality within the Pike Lake watershed.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Pike Lake would entail a total capital cost of about $41,300, and an average annual operation and maintenance cost of about $7,700. The total 50-year present worth cost of these source control measures is $124,800, with an equivalent annual cost of $8,000.

Pine Lake

Pine Lake is a 703-acre lake located in the Town of Merton in Waukesha County. The lake is internally drained. Certain geomorphological characteristics of Pine Lake are set forth in Table C-256, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[27] Map C-86 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-86, all significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 163 privately owned onsite sewage disposal systems—84 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-257, all direct sources combined contribute about 800 pounds of phosphorus annually to Pine Lake. The major sources of phosphorus in the lake watershed are atmospheric loading and septic tank system loadings. Also, as indicated in Table C-257, urban land uses in the watershed are expected to increase by about 70 percent under planned year 2000 land cover conditions, with annual total phosphorus loading to the lake expected to increase to about 1,600 pounds as a result of construction activity and increased urban land runoff. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.01 milligram per liter (mg/l) and 0.03 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Pine Lake which slightly exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

[27] *Report on Pine Lake, National Eutrophication Survey, U.S. Environmental Protection Agency.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-258, along with the associated costs and anticipated effectiveness. Measures to control construction activity contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-258 may include sediment covering or aeration

### Table C-256

### GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PINE LAKE

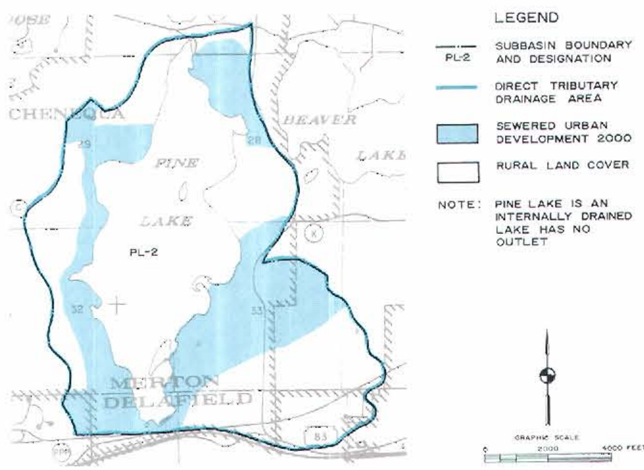
| Characteristic | Description |
|---|---|
| Surface Area | 703 acres |
| Direct Tributary Drainage Area | 1,528 acres |
| Shoreline | 7.3 miles |
| Depth | |
| Maximum | 85 feet |
| Mean | 38.4 feet |
| Volume | 26,995 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 572 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; high nutrient concentrations; deoxygenated hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.51 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Map C-86

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PINE LAKE: 2000




Pine Lake has a direct tributary drainage area of about 1,528 acres. About 458 acres, or 30 percent of the drainage area, are planned to be in rural land cover, and 1,070 acres, or 70 percent, to be in urban land cover. Over the planning period an average of about 22 acres may be expected to be converted to urban land cover. It is estimated that a 33 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

### Table C-257

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PINE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 611 | 79 | 10.4 | 1,048 | 122 | 7.8 |
| Land under Development—Construction Activities (acres) | – | – | – | 22 | 1,002 | 64.2 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 84 | 243 | 31.9 | 10 | 29 | 1.9 |
| Rural Land Cover (acres) | 917 | 88 | 11.5 | 458 | 54 | 3.5 |
| Livestock Operations (animal units) | – | – | – | – | – | |
| Atmospheric Contribution (acres of receiving surface water) | 703 | 352 | 46.2 | 703 | 352 | 22.6 |
| Total | – | 762 | 100.0 | – | 1,559 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

## Table C-258

### WATER QUALITY MANAGEMENT MEASURES FOR PINE LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 70 |
| Minimum Rural Conservation Practices | $ 100 | $ 1,200 | $ 100 | $ 14,700 | $ 14,800 | Minimal | $ 900 | $ 900 | | |
| Construction Erosion Control Practices[d] | 1,016,400 | 8,800 | 762,900 | 138,700 | 901,600 | 48,400 | 8,600 | 57,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,400 | Minimal | 20,100 | 20,100 | Minimal | 1,300 | 1,300 | | |
| Total | 1,016,500 | 11,400 | 763,000 | 173,500 | 936,500 | 48,400 | 10,800 | 59,200 | | |
| Macrophyte Harvesting[e] | 37,300 | 5,200 | 27,900 | 82,000 | 109,900 | 1,800 | 5,200 | 7,000 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 90,000 | 2,300 | 67,300 | 36,300 | 102,800 | 4,300 | 2,300 | 6,500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[g,h] | 1,406,000 | – | 1,050,700 | – | 1,050,700 | 66,700 | – | 66,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Pine Lake drainage basin include a capital cost over the period of 1975-2000 of $2,652,000, an average annual operation and maintenance cost of $20,000, and a total 50-year present worth cost of $1,799,400.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Pine Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Pine Lake drainage basin include a capital cost over the period of 1975-2000 of $238,500, an average annual operation and maintenance cost of $3 700, and a total 50-year present worth cost of $260,900.*

[d] *Cost estimated to control erosion from the estimated 22.3 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 40 acres of Pine Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[h] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

of the hypolimnion. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Pine Lake requires that the recommended level of nutrient input reductions be achieved.

Recent observations on the water quality of Pine Lake conducted by the Wisconsin Department of Natural Resources indicate that Pine Lake may be nitrogen limited. If this phenomena is confirmed by a more detailed study, the recommended measures for phosphorus reduction would still be considered reasonable for cost estimates at the regional level, but may have to be refined to reflect the needed nitrogen controls.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Pine Lake would entail a total capital cost of about $1,016,500, and an average annual operation and maintenance cost of about $11,400. The total 50-year present worth cost of these source control measures is $936,500, with an equivalent annual cost of $59,400. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $90,000 for hypolimnetic aeration to $1,406,000 for sediment covering. The total present worth costs of these lake harvesting rehabilitation techniques would range from $102,800 for hypolmnetic aeration to $1,050,700 for sediment covering.

Pretty Lake

Pretty Lake is a 64-acre lake located in the Town of Ottawa in Waukesha County. The lake is internally drained. Certain geomorphological characteristics of Pretty Lake are set forth in Table C-259, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-87 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-87, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 117 privately owned onsite sewage disposal systems—28 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-260, all sources combined contribute about 140 pounds of phosphorus annually to Pretty Lake. The major source of phosphorus in the lake watershed is malfunctioning septic tank systems. Also as indicated in Table C-260, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected

Table C-259

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF PRETTY LAKE

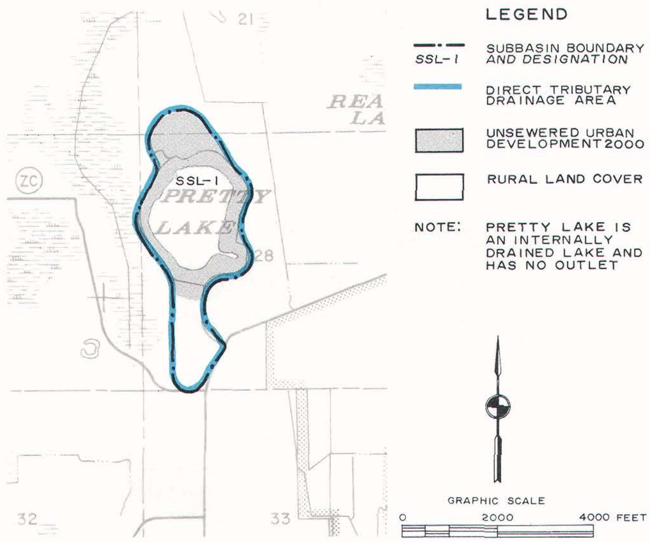
| Characteristic | Description |
|---|---|
| Surface Area | 64 acres |
| Direct Tributary Drainage Area | 106 acres |
| Shoreline | 1.25 miles |
| Depth | |
| Maximum | 31 feet |
| Mean | 9.2 feet |
| Volume | 589 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 424 persons |
| General Existing Water Quality Conditions: | Moderate macrophyte growth; moderate nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.62 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

Map C-87

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF PRETTY LAKE: 2000




Pretty Lake has a direct tributary drainage area of about 106 acres. About 46 acres, or 43 percent of the drainage area, are planned to be in rural land cover, and 60 acres, or 57 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-260

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO PRETTY LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 60 | 19 | 13.8 | 60 | 19 | 13.8 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 28 | 81 | 58.7 | 28 | 81 | 58.7 |
| Rural Land Cover (acres) | 46 | 6 | 4.3 | 46 | 6 | 4.3 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 64 | 32 | 23.2 | 64 | 32 | 23.2 |
| Total | – | 138 | 100.0 | – | 138 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

to result in total phosphorus concentrations in Pretty Lake which meet the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-261, along with the associated costs and anticipated effectiveness. Measures to control malfunctioning septic tank systems appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other measures which should be implemented include: minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-261 may include nutrient inactivation, hypolimnetic aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as macrophyte harvesting may be used to control the weed growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Pretty Lake requires that the recommended level of nutrient input reductions be achieved.

**Table C-261**

**WATER QUALITY MANAGEMENT MEASURES FOR PRETTY LAKE IN WAUKESHA COUNTY**

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Mangement[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 50 |
| Minimum Rural Conservation Practices | $ < 100 | $ 100 | Minimal | $ 1,000 | $ 1,000 | Minimal | $ 100 | $ 100 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 1,500 | 1,500 | Minimal | 100 | 100 | | |
| Total | 100 | 200 | Minimal | 2,500 | 2,500 | Minimal | 200 | 200 | | |
| Macrophyte Harvesting[b] | 2,800 | 400 | 2,100 | 6,100 | 8,200 | 100 | 400 | 500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 3,600 | 100 | 2,700 | 1,400 | 4,100 | 1,200 | 100 | 300 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 6,400 | -- | 4,800 | -- | 4,800 | 300 | -- | 300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,g] | 128,000 | -- | 95,600 | -- | 95,600 | 6,100 | -- | 6,100 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 598,700 | -- | 447,400 | -- | 447,400 | 28,400 | -- | 28,400 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Pretty Lake. However, because spetic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Pretty Lake drainage basin include a capital cost over the period of 1975-2000 of $126,000, an average annual operation and maintenance cost of $3,800, and a total 50-year present worth cost of $198,700.*

[b] *Cost estimated to harvest macrophytes from the 3 acres of Pretty Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 9.2 feet.*

[g] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Pretty Lake would entail a total capital cost of less than $100, and an average annual operation and maintenance cost of about $200. The total 50-year present worth cost of these source control measures is $2,500, with an equivalent annual cost of $200. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $3,600 for hypolimnetic aeration to $598,700 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,100 for hypolimnetic aeration to $447,400 for dredging.

Rice Lake

Rice Lake is a 137-acre lake located in the Town of Whitewater in Walworth County. The lake drains to Turtle Creek. Certain geomorphological characteristics of Rice Lake are set forth in Table C-262, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-88 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-88, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 27 privately owned onsite sewage disposal systems—only one of which was located in an area covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

Table C-262

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF RICE LAKE

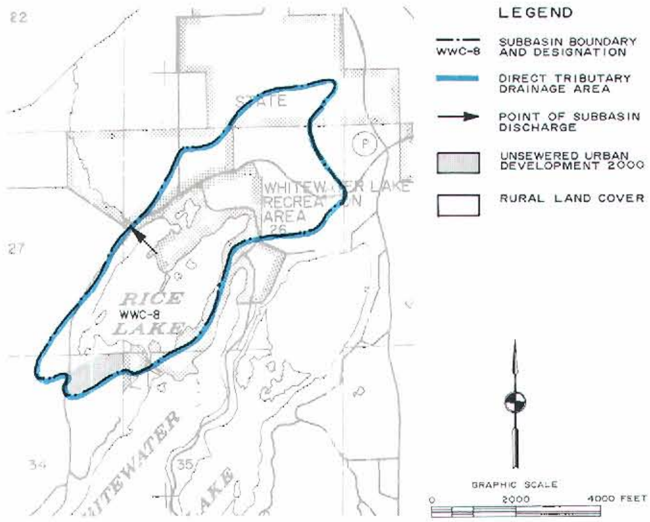
| Characteristic | Description |
|---|---|
| Surface Area | 137 acres |
| Direct Tributary Drainage Area | 348 acres |
| Shoreline | 3.0 miles |
| Depth | |
| Maximum | 10 feet |
| Mean | 4 feet |
| Volume | 548 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 85 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; frequent fish winterkill |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-88

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF RICE LAKE: 2000




Rice Lake has a direct tributary drainage area of about 348 acres. About 173 acres, or 50 percent of the drainage area, are planned to be in rural land cover, and 175 acres, or 50 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-263

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO RICE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 175 | 22 | 5.6 | 175 | 22 | 5.6 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | less than 5 | 3 | 0.8 | less than 5 | 3 | 0.8 |
| Rural Land Cover (acres) | 173 | 21 | 5.3 | 173 | 21 | 5.3 |
| Livestock Operations (animal units) | 42 | 277 | 70.7 | 42 | 277 | 70.7 |
| Atmospheric Contribution (acres of receiving surface water) | 137 | 69 | 17.6 | 137 | 69 | 17.6 |
| Total | – | 392[c] | 100.0 | – | 392[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 400 pounds per year and the year 2000 anticipated phosphorus load of 100 pounds per year contributed by the drainage from the Whitewater Lake outlet.*

*Source: SEWRPC.*

As indicated in Table C-263, all direct sources combined contribute about 400 pounds of phosphorus annually to Rice Lake. An additional 400 pounds of phosphorus enter the lake annually from Whitewater Lake. The major source of phosphorus in the lake watershed is livestock operations. Also, as indicated in Table C-263, land uses and direct phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The load from Whitewater Lake, however, is expected to be reduced to about 100 pounds as a result of lake quality management measures recommended for the Whitewater Lake watershed. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.04 milligram per liter (mg/l) and 0.02 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Rice Lake which exceed and equal, respectively, the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-264, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom sub-

Table C-264

WATER QUALITY MANAGEMENT MEASURES FOR RICE LAKE IN WALWORTH COUNTY

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | |
| Septic Tank System Mangement[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 3,700 | $ 300 | $ 2,800 | $ 3,700 | $ 6,500 | $ 200 | $ 200 | $ 400 | | |
| Minimum Rural Conservation Practices | 100 | 500 | 100 | 6,300 | 6,400 | Minimal | 400 | 400 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 1,200 | 1,200 | Minimal | 100 | 100 | | 50 |
| Total | 3,800 | 900 | 2,900 | 11,200 | 14,100 | 200 | 700 | 900 | | |
| Macrophyte Harvesting[b] | 31,700 | 4,400 | 23,700 | 69,700 | 93,400 | 1,500 | 4,400 | 5,900 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[e] | 10,000 | 300 | 7,500 | 3,900 | 11,400 | 500 | 300 | 800 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 13,700 | -- | 10,200 | -- | 10,200 | 600 | -- | 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 274,000 | -- | 204,800 | -- | 204,800 | 13,000 | -- | 13,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 2,430,800 | -- | 1,816,500 | -- | 1,816,500 | 115,200 | -- | 115,200 | Deepen lake; reduce macrophyte growth | No additional reduction |

*[a] The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Rice Lake. However, because spetic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Rice Lake drainage basin include a capital cost over the period of 1975-2000 of $4,500, an average annual operation and maintenance cost of $800, and a total 50-year present worth cost of $29,800.*

*[b] Cost estimated to harvest macrophytes from the 34 acres of Rice Lake subject to excessive macrophyte growth.*

*[c] Cost to aerate 50 acres of the surface area of Rice Lake.*

*[d] The cost for nutrient inactivation is for treating the entire lake with alum.*

*[e] Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*[f] The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*[g] Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 4.0 feet.*

*Source: SEWRPC.*

strate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-264 may include nutrient inactivation, aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as macrophyte harvesting may be used to control macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Rice Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Rice Lake would entail a total capital cost of about $3,800, and an average annual operation and maintenance cost of about $900. The total 50-year present worth cost of these source control measures is $14,100, with an equivalent annual cost of $900. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $10,000 for aeration to $2,430,800 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $10,200 for nutrient inactivation to $1,816,500 for dredging.

School Section Lake

School Section Lake is a 125-acre lake located in the Town of Ottawa in Waukesha County. The lake drains to the Bark River via an unnamed tributary. Certain geomorphological characteristics of School Section Lake are set forth in Table C-265, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions.[28] Map C-89 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-89, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 58 privately owned onsite sewage disposal systems—three of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

[28] *In addition to this discussion, important physical data about School Section Lake have been set forth in a report entitled School Section Dike Rehabilitation Study, prepared by Donohue and Associates, Inc. under contract to the Waukesha County Park and Planning Commission.*

As indicated in Table C-266, all direct sources combined contribute about 100 pounds of phosphorus annually to School Section Lake. An additional 300 pounds of phosphorus enter the lake annually from the upstream watershed. The major direct source of phosphorus in the lake watershed is the contribution from the atmosphere. Also, as indicated in Table C-266, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.02 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in School Section Lake which do not exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-267, along with the associated costs and anticipated effectiveness. In addition, it should be noted that

Table C-265

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SCHOOL SECTION LAKE

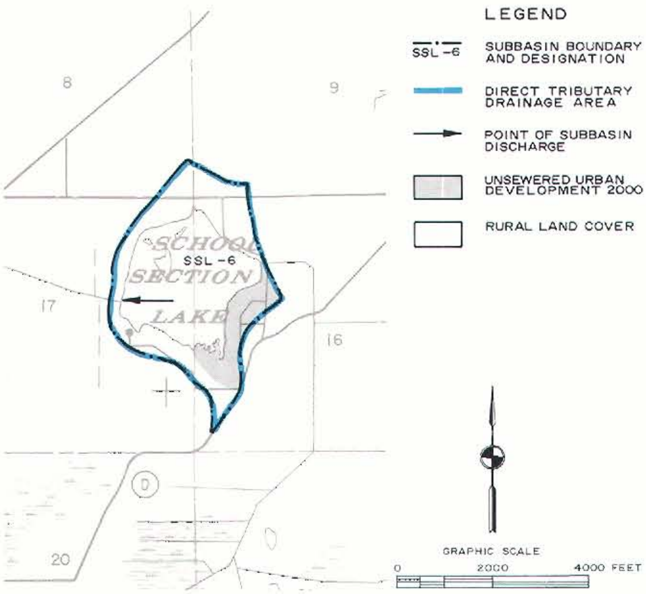
| Characteristic | Description |
|---|---|
| Surface Area | 125 acres |
| Direct Tributary Drainage Area | 135 acres |
| Shoreline | 1.90 miles |
| Depth | |
| Maximum | 8.0 feet |
| Mean | 2.5 feet |
| Volume | 312 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 409 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth in shallow areas; moderate nutrient concentrations; potential winter fishkills |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.62 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

## Map C-89

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SCHOOL SECTION LAKE: 2000




School Section Lake has a direct tributary drainage area of about 135 acres. About 82 acres, or 61 percent of the drainage area, are planned to be in rural land cover, and 53 acres, or 39 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that no reduction in nonpoint source pollutant runoff will be required in the drainage area to satisfy water quality standards. To provide minimum water quality control, a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

## Table C-266

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SCHOOL SECTION LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 53 | 12 | 13.0 | 53 | 12 | 13.0 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | <5 | 9 | 9.0 | <5 | 9 | 9.0 |
| Rural Land Cover (acres) | 82 | 13 | 14.0 | 82 | 13 | 14.0 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 125 | 62 | 64.0 | 125 | 62 | 64.0 |
| Total | – | 96[c] | 100.0 | – | 96[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated and year 2000 anticipated phosphorus load of 300 pounds per year contributed by the upstream drainage of the School Section Lake watershed.*

*Source: SEWRPC.*

the repair of the dike—built as a Works Progress Administration (WPA) project to control leakage and maintain the lake depth—is essential to the protection of lake water quality, and desired recreational use and fish and other aquatic life use objectives. Accordingly, the proposed dike repair project, for which Waukesha County committed $56,800 from the 1978 budget, is endorsed as a sound water quality management measure, and is taken as a committed decision for purposes of this analyses. Measures to control the contribution of phosphorus include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-267 may include aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in School Section Lake requires that the recommended level of nutrient concentrations be achieved

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to School Section Lake would entail a total capital cost of about $100, and an average annual operation and maintenance cost of about $200. The total 50-year present worth cost of these source control measures is $3,100, with an equivalent annual cost of $200. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $6,000 for aeration to $2,520,300 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $6,900 for aeration to $1,883,400 for dredging.

### Silver Lake

Silver Lake is a 222-acre lake located in the Town of Summit in Waukesha County. The lake drains to Battle Creek. Certain geomorphological characteristics of Silver Lake are set forth in Table C-268, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-90 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-90, the majority of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of

## Table C-267

### WATER QUALITY MANAGEMENT MEASURES FOR SCHOOL SECTION LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Septic Tank System Mangement[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ <100 | $ 100 | Minimal | $ 1,800 | $ 1,800 | Minimal | $ 100 | $ 100 | | |
| Low Cost Urban Land Management Practices | Minimal | 100 | Minimal | 1,300 | 1,300 | Minimal | 100 | 100 | | |
| Total | 100 | 200 | 0 | 3,100 | 3,100 | Minimal | 200 | 200 | | 10 |
| Macrophyte Harvesting[b] | 28,900 | 4,000 | 21,600 | 63,500 | 85,100 | 1,400 | 4,000 | 5,400 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 6,000 | 200 | 4,500 | 2,400 | 6,900 | 300 | 100 | 400 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Sediment Covering[d,f] | 250,000 | – | 186,800 | – | 186,800 | 11,900 | – | 11,900 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[e,f] | 2,520,300 | – | 1,883,400 | – | 1,883,400 | 119,500 | – | 119,500 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of School Section Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the School Section Lake drainage basin include a capital cost over the period of 1975-2000 of $13,500, an average annual operation and maintenance cost of $1,800, and a total 50-year present worth cost of $76,600.*

[b] *Cost estimated to harvest macrophytes from the 31 acres of School Section Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate 39 acres of the lake.*

[d] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[e] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 2.5 feet.*

[f] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

1975, an estimated 176 privately owned onsite sewage disposal systems—43 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-269, all sources combined contribute about 430 pounds of phosphorus annually to Silver Lake. The major sources of phosphorus in the lake watershed are urban land runoff and malfunctioning septic tank systems. Also, as indicated in Table C-269, urban land uses in the watershed are expected to increase by about 66 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be increased to about 1,900 pounds as a result of increased construction activity. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.02 milligram per liter (mg/l) and 0.10 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenances of a warmwater fishery and recreational use classification. Anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Silver Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures—applied in alternative

Table C-268

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF SILVER LAKE

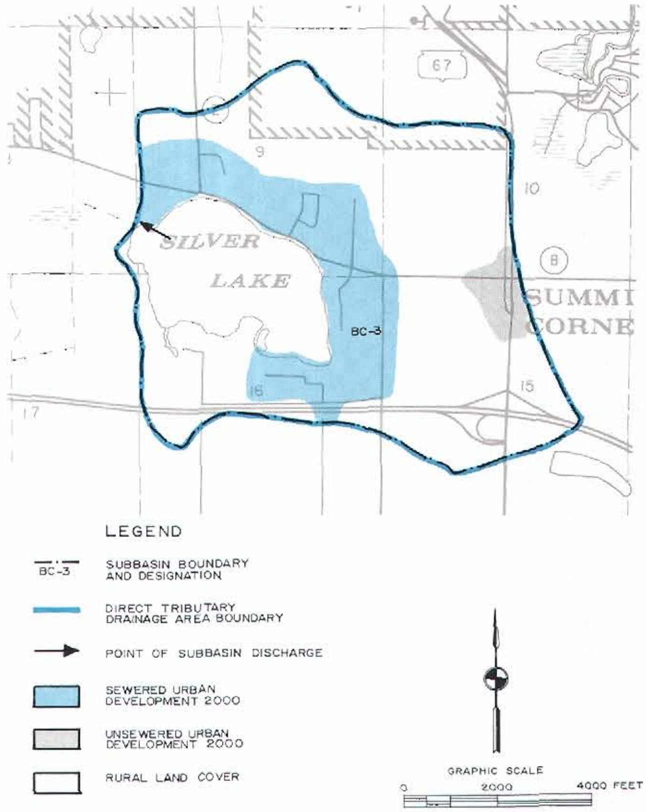
| Characteristic | Description |
|---|---|
| Surface Area | 222 acres |
| Direct Tributary Drainage Area | 1,161 acres |
| Shoreline | 2.7 miles |
| Depth | |
| Maximum | 44 feet |
| Mean | 31.5 feet |
| Volume | 6,993 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 563 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; high nutrient concentrations; lack of oxygen in hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-90

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF SILVER LAKE: 2000




Silver Lake has a direct tributary drainage area of about 1,161 acres. About 232 acres, or 20 percent of the drainage area, are planned to be in rural land cover, and 929 acres, or 80 percent, to be in urban land cover. Over the planning period an average of about 35 acres may be expected to be converted annually to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-269

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO SILVER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 537 | 134 | 31.5 | 894 | 106 | 5.7 |
| Land under Development—Construction Activities (acres) | – | – | – | 35 | 1,595 | 85.5 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 43 | 125 | 29.3 | 10 | 29 | 1.6 |
| Rural Land Cover (acres) | 624 | 56 | 13.1 | 232 | 23 | 1.2 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 222 | 111 | 26.1 | 222 | 111 | 6.0 |
| Total | – | 426 | 100.0 | – | 1,864 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-270, along with the associated costs and anticipated effectiveness. Measures to control construction erosion contributions appear to be the most effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

## Table C-270

### WATER QUALITY MANAGEMENT MEASURES FOR SILVER LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 80 |
| Minimum Rural Conservation Practices | $ 100 | $ 800 | $ 100 | $ 10,200 | $ 10,300 | Minimal | $ 600 | $ 600 | | |
| Construction Erosion Control Practices[d] | 1,635,500 | 14,200 | 1,227,500 | 223,200 | 1,450,700 | $ 77,900 | 14,200 | 92,100 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,100 | Minimal | 16,300 | 16,300 | Minimal | 1,000 | 1,000 | | |
| Total | 1,635,600 | 16,100 | 1,227,600 | 249,700 | 1,477,300 | 77,900 | 15,800 | 93,700 | | |
| Macrophyte Harvesting[e] | 15,800 | 2,200 | 11,800 | 34,800 | 46,600 | 800 | 2,200 | 3,000 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeragion[f] | 22,200 | 600 | 16,600 | 8,700 | 25,300 | 1,100 | 600 | 1,700 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 11,100 to 22,200 | – | 8,300 to 16,600 | – | 8,300 to 16,600 | 500 to 1,100 | – | 500 to 1,100 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 444,000 | – | 331,800 | – | 331,800 | 21,000 | – | 21,000 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Silver Lake drainage basin include a capital cost over the period of 1975-2000 of $1,748,000, an average annual operation and maintenance cost of $13,100, and a total 50-year present worth cost of $1,186,000.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Silver Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Silver Lake drainage basin include a capital cost over the period of 1975-2000 of $45,000, an average annual operation and maintenance cost of $1,300, and a total 50-year present worth cost of $69,200.*

[d] *Cost estimated to control erosion from the estimated 35.4 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 17 acres of Silver Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-270 may include hypolimnetic aeration, nutrient inactivation, and sediment covering. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Silver Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint pollution control measures to control the nutrient inputs to Silver Lake would entail a total capital cost of about $1,635,600, and an average annual operation and maintenance cost of about $16,100. The total 50-year present worth cost of these source control measures is $1,477,300, with an equivalent annual cost of $93,700. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $11,100 for nutrient inactivation to $444,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $8,300 for nutrient inactivation to $331,800 for sediment covering.

Tripp Lake

Tripp Lake is a 115-acre lake located in the City of Whitewater in Walworth County. The lake drains to Whitewater Creek through Cravath Lake. Certain geomorphological characteristics of Tripp Lake are set forth in Table C-271, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-91 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-91, all significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 23 privately owned onsite sewage disposal systems—11 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area. The sanitary sewer service area of the watershed is proposed to be extended under planned year 2000 conditions.

As indicated in Table C-272, all direct sources combined contribute about 500 pounds of phosphorus annually to Tripp Lake. An additional 1,000 pounds of phosphorus enter the lake annually from Whitewater Creek. The major source of phosphorus in the lake watershed is Whitewater Creek inflow. Also, as indicated in Table C-272, urban land uses in the watershed are expected to increase by about 170 percent under planned year 2000

Table C-271

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF TRIPP LAKE

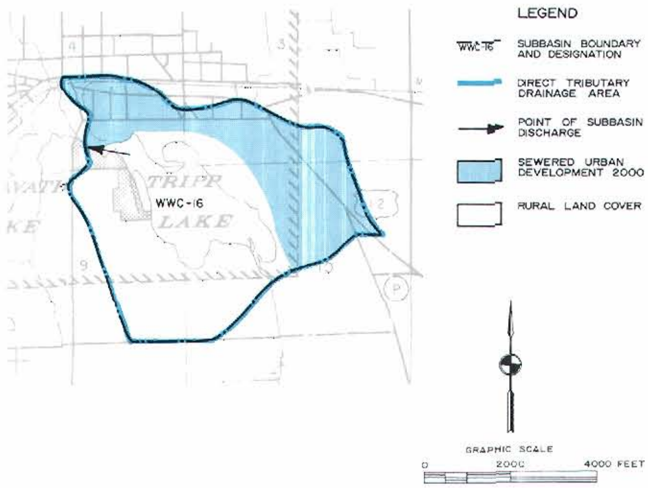
| Characteristic | Description |
|---|---|
| Surface Area | 115 acres |
| Direct Tributary Drainage Area | 554 acres |
| Shoreline | 2.9 miles |
| Depth | |
| Maximum | 8 feet |
| Mean | 3.3 feet |
| Volume | 380 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 285 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; nuisance macrophyte growth; low transparency, occasional low dissolved oxygen |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-91

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF TRIPP LAKE: 2000




Tripp Lake has a direct tributary drainage area of about 554 acres. About 305 acres, or 55 percent of the drainage area, are planned to be in rural land cover, and 249 acres, or 45 percent, to be in urban land cover. Over the planning period an average of about seven acres may be expected to be converted to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of agricultural cropping practices—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-272

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO TRIPP LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 90 | 37 | 7.7 | 242 | 75 | 14.8 |
| Land under Development—Construction Activities (acres) | 7 | 312 | 64.9 | 7 | 312 | 61.7 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 11 | 32 | 6.6 | 11 | 32 | 6.3 |
| Rural Land Cover (acres) | 457 | 43 | 8.9 | 305 | 30 | 5.9 |
| Livestock Operations (animal units) | – | – | – | – | – | – |
| Atmospheric Contribution (acres of receiving surface water) | 115 | 57 | 11.9 | 115 | 57 | 11.3 |
| Total | – | 481[c] | 100.0 | – | 506[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 1,000 pounds per year or the year 2000 anticipated phosphorus load of 700 pounds per year contributed by the upstream drainage from Whitewater Creek.*

*Source: SEWRPC.*

conditions, with annual direct phosphorus loadings to the lake expected to increase slightly. Whitewater Creek loads are expected to decrease to 700 pounds as a result of upstream watershed management practices. The estimated total phosphorus concentrations during spring estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.04 milligram per liter (mg/l) and 0.03 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Tripp Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

**Table C-273**

**WATER QUALITY MANAGEMENT MEASURES FOR TRIPP LAKE IN WALWORTH COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
| Sanitary Sewer Service[b] | | | | | | | | | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Minimum Rural Conservation Practices | $ <100 | $ 300 | $ <100 | $ 3,500 | $ 3,600 | $ 0 | $ 200 | $ 200 | | |
| Construction Erosion Control Practices[d] | 318,800 | 2,800 | 239,300 | 43,500 | 282,800 | 15,200 | 2,800 | 18,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 300 | Minimal | 4,000 | 4,000 | Minimal | 300 | 300 | | 70[j] |
| Total | 318,900 | 3,400 | 239,400 | 51,000 | 290,400 | 15,200 | 3,300 | 18,500 | | |
| Macrophyte Harvesting[e] | 35,400 | 4,900 | 26,500 | 77,900 | 104,400 | 1,700 | 4,900 | 6,600 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Lake Draw Down | Minimal | | Minimal | | | Minimal | | | Sediment consolidation | No additional reduction |
| Aeration[f] | 6,000 | 200 | 4,500 | 2,400 | 6,900 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 11,500 | – | 8,600 | – | 8,600 | 500 | – | 500 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i,k] | 230,000 | – | 171,900 | – | 171,900 | 10,900 | – | 10,900 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[i,j,k] | 2,170,300 | – | 1,621,900 | – | 1,621,900 | 102,900 | – | 102,900 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Lower Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Lower Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Tripp Lake drainage basin include a capital cost over the period of 1975-2000 of $476,000, an average annual operation and maintenance cost of $5,600, and a total 50-year present worth cost of $355,100.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Tripp Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Tripp Lake drainage basin include a capital cost over the period of 1975-2000 of $49,500, an average annual operation and maintenance cost of $500 and a total 50-year present worth cost of $45,200.*

[d] *Cost estimated to control erosion from the estimated 6.9 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 38 acres of Tripp Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate 30 acres of Tripp Lake.*

[g] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *These costs may be significantly reduced if the dam is opened and the lake dewatered. This action, however, has the distinct disadvantage of leaving the lakebed dry for a significant period of time, and resulting in a dramatic impact on the biological composition of the lake.*

[j] *The reduction in the direct phosphorus load to Tripp Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Whitewater Creek if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Tripp Lake is to meet the water quality criteria for recreation and warmwater fishery.*

[k] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures identified. These measures are set forth in Table C-273, along with the associated costs and anticipated effectiveness. Measures to control construction activity contributions appear to be the most effective way to substantially reduce direct phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands. These measures alone will not reduce Tripp Lake phosphorus loadings to recommended levels since most of the Tripp Lake load stems from Whitewater Creek. Implementation of similar measures in the Whitewater Creek watershed as recommended in the nonpoint source element to the Rock River watershed would reduce total Tripp Lake phosphorus loads to recommended levels.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-273 may include aeration, nutrient inactivation, sediment covering, and dredging. A fifth alternative, dewatering the lake and allowing the sediments to dry and consolidate, would have little monetary cost but would entail significant environmental and aesthetic effects resulting from the drying of the lake. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Tripp Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures in the direct tributary watershed to control the nutrient inputs to Tripp Lake would entail a total capital cost of about $318,900, and an average annual operation and maintenance cost of about $3,400. The total 50-year present worth cost of these source control measures is $290,400, with an equivalent annual cost of $18,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $6,000 for aeration to $2,170,300 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $6,900 for aeration to $1,621,900 for dredging.

Turtle Lake

Turtle Lake is a 140-acre lake located in the Town of Richmond in Walworth County. The lake forms the headwater of Turtle Creek. Certain geomorphological characteristics of Turtle Lake are set forth in Table C-274, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-92 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-92, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 160 privately owned onsite sewage disposal systems—112 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the watershed area.

As indicated in Table C-275, all sources combined contribute about 1,700 pounds of phosphorus annually to Turtle Lake. The major sources of phosphorus in the lake watershed are livestock operations and septic tank systems. The existing land uses are not expected to change significantly under planned year 2000 land cover conditions. Therefore, unless reduced by the implementation of nonpoint source control measures, phosphorus loadings from livestock and septic tank systems may be expected to continue to be the primary sources of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentration during spring overturn under both existing and year 2000 lake and drainage basin characteristics is 0.14 milligram

Table C-274

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF TURTLE LAKE

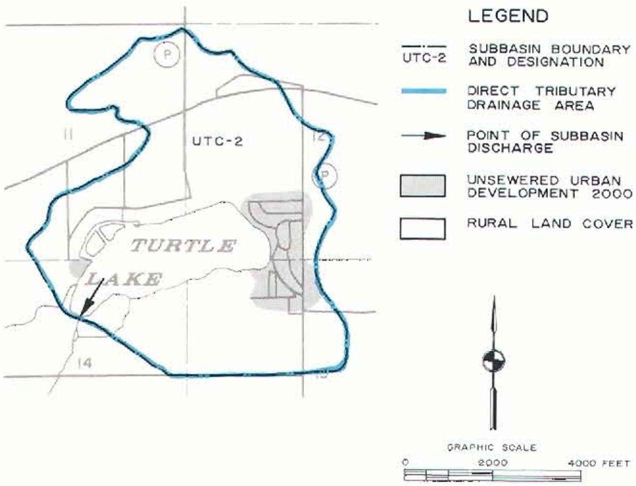
| Characteristic | Description |
|---|---|
| Surface Area | 140 acres |
| Direct Tributary Drainage Area | 748 acres |
| Shoreline | 2.3 miles |
| Depth | |
| Maximum | 35 feet |
| Mean | 14.4 feet |
| Volume | 2,016 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 501 persons |
| General Existing Water Quality Conditions: | Generally good, except for macrophyte growth in the littoral zone and a lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.13 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

### Map C-92

### PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF TURTLE LAKE: 2000




Turtle Lake has a direct tributary drainage area of about 748 acres. About 635 acres, or 85 percent of the drainage area, are planned to be in rural land cover, and 113 acres, or 15 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed is expected to be converted to urban land cover. It is estimated that an 85 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. To provide for water quality control, a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program—should be implemented in the lake drainage area.

*Source: SEWRPC.*

### Table C-275

### ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO TURTLE LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 113 | 22 | 1.3 | 113 | 22 | 1.3 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 112 | 324 | 19.2 | 112 | 324 | 19.2 |
| Rural Land Cover (acres) | 636 | 67 | 4.0 | 635 | 67 | 4.0 |
| Livestock Operations (animal units) | 182 | 1,201 | 71.3 | 182 | 1,201 | 71.3 |
| Atmospheric Contribution (acres of receiving surface water) | 140 | 70 | 4.2 | 140 | 70 | 4.2 |
| Total | – | 1,684 | 100.0 | – | 1,684 | 100.0 |

[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Turtle Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-276, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may continue to provide a suitable bottom substrate and nutrient source for excessive macrophyte growth and may release nutrients to the water body, resulting in continued poor water quality. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures may include hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures, such as weed harvesting, may be used to control temporarily the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Turtle Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Turtle Lake would entail a total capital cost of about \$77,300, and an average annual operation and maintenance cost of about \$6,800. The total 50-year present worth cost of these nonpoint source control measures, useful in comparing the long-term costs of alternative control measures, is \$138,400, with an equivalent annual cost of \$9,000. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from \$7,000 for nutrient inactivation to \$280,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from \$5,200 for nutrient inactivation to \$209,200 for sediment covering.

Table C-276

WATER QUALITY MANAGEMENT MEASURES FOR TURTLE LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis: Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 85 |
| Livestock Waste Control | $ 77,200 | $ 5,500 | $ 57,700 | $ 64,200 | $ 121,900 | $ 3,700 | $ 4,100 | $ 7,800 | | |
| Minimum Rural Conservation Practices | 100 | 1,100 | 100 | 13,600 | 13,700 | >100 | 900 | 1,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 200 | Minimal | 2,800 | 2,800 | Minimal | 200 | 200 | | |
| Total | 77,300 | 6,800 | 57,800 | 80,600 | 138,400 | 3,800 | 5,200 | 9,000 | | |
| Macrophyte Harvesting[b] | 28,000 | 3,900 | 20,900 | 61,500 | 82,400 | 1,300 | 3,900 | 5,200 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 14,000 | 400 | 10,500 | 5,500 | 16,000 | 700 | 400 | 1,100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 7,000 to 14,000 | – | 5,200 to 10,500 | – | 5,200 to 10,500 | 300 to 700 | – | 300 to 700 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,f] | 280,000 | – | 209,200 | – | 209,200 | 13,300 | – | 13,300 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Turtle Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Turtle Lake drainage basin include a capital cost over the period of 1975-2000 of $504,000, an average annual operation and maintenance cost of $5,900, and a total 50-year present worth cost of $487,600.*

[b] *Cost estimated to harvest macrophytes from the 30 acres of Turtle Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC.*

Upper Nashotah Lake

Upper Nashotah Lake is a 133-acre lake located in the Town of Summit in Waukesha County. The lake drains to the Bark River via Lower Nashotah Lake and the Nemahbin Lakes. Certain geomorphological characteristics of Upper Nashotah Lake are set forth in Table C-277, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-93 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-93, all significant urban land areas in the tributary watershed area are proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 69 privately owned onsite sewage disposal systems—33 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the watershed area.

As indicated in Table C-278, all sources combined contribute about 2,000 pounds of phosphorus annually to Upper Nashotah Lake. The major source of phosphorus in the lake watershed is livestock operations. Also as indicated in Table C-278, urban land uses in the watershed are expected to increase by about 110 percent under planned year 2000 land cover conditions, with annual total phosphorus loadings to the lake expected to be increased to about 2,400 pounds as a result of an expected increase in construction activities needed for the development of urban land. Livestock operations, however, are expected to remain the primary source of phosphorus to the lake under anticipated year 2000 conditions. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.17 milligram per liter (mg/l) and 0.21 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classifications. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Upper Nashotah Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

Table C-277

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF UPPER NASHOTAH LAKE

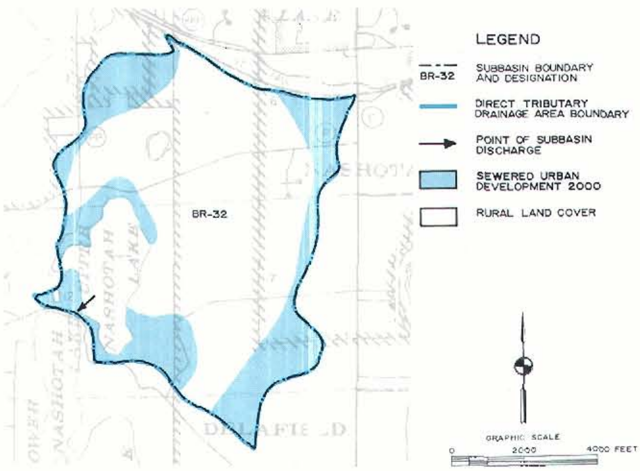
| *Characteristic* | Description |
|---|---|
| Surface Area | 133 acres |
| Direct Tributary Drainage Area | 1,257 acres |
| Shoreline | 2.30 miles |
| Depth | |
| Maximum | 53 feet |
| Mean | 21 feet |
| Volume | 2,820 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 221 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms and excessive macrophyte growth; high nutrient concentrations; and lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Map C-93

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF UPPER NASHOTAH LAKE: 2000




Upper Nashotah Lake has a direct tributary drainage area of about 1,257 acres. About 943 acres, or 75 percent of the drainage area, are planned to be in rural land cover, and 314 acres, or 25 percent, to be in urban land cover. Over the planning period an average of about 10 acres may be expected to be converted to urban land cover. It is estimated that a 90 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices, construction erosion controls, and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-278

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO UPPER NASHOTAH LAKE: 1975 and 2000

| | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| Source of Phosphorus | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 145 | 38 | 1.9 | 304 | 80 | 3.3 |
| Land under Development—Construction Activities (acres) | – | – | – | 10 | 463 | 19.0 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 33 | 95 | 4.7 | 14 | 40 | 1.6 |
| Rural Land Cover (acres) | 1,112 | 106 | 5.3 | 943 | 86 | 3.5 |
| Livestock Operations (animal units) | 258 | 1,703 | 84.8 | 258 | 1,703 | 69.8 |
| Atmospheric Contribution (acres of receiving surface water) | 133 | 67 | 3.3 | 133 | 67 | 2.8 |
| Total | – | 2,009 | 100.0 | – | 2,439 | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-279, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the extension of sanitary sewer service, improved septic tank management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through

## Table C-279

### WATER QUALITY MANAGEMENT MEASURES FOR UPPER NASHOTAH LAKE IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis, Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Economic Analysis, Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Septic Tank System Management[c] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 22,700 | $ 1,900 | $ 17,000 | $ 22,800 | $ 39,800 | $ 1,100 | $ 1,400 | $ 2,500 | | |
| Minimum Rural Conservation Practices | 200 | 1,800 | 200 | 22,000 | 22,200 | 100 | 1,400 | 1,500 | | |
| Construction Erosion Control Practices[d] | 462,000 | 4,000 | 346,800 | 63,100 | 409,900 | 22,000 | 4,000 | 26,000 | | |
| Low Cost Urban Land Management Practices | Minimal | 400 | Minimal | 5,500 | 5,500 | Minimal | 400 | 400 | | 90 |
| Total | 484,900 | 8,100 | 364,000 | 113,400 | 477,400 | 23,200 | 7,200 | 30,400 | | |
| Macrophyte Harvesting[e] | 18,600 | 2,600 | 13,900 | 41,000 | 54,900 | 900 | 2,600 | 3,500 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[f] | 14,000 | 400 | 10,500 | 6,300 | 16,800 | 700 | 400 | 1,100 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[g] | 7,000 to 13,300 | – | 5,200 to 9,900 | – | 5,200 to 9,900 | 300 to 600 | – | 300 to 600 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[h,i] | 266,000 | – | 198,800 | – | 198,800 | 12,600 | – | 12,600 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

[a] *The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

[b] *Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Upper Nashotah Lake drainage basin include a capital cost over the period of 1975-2000 of $488,000, an average annual operation and maintenance cost of $13,700, and a total 50-year present worth cost of $331,100.*

[c] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Upper Nashotah Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Upper Nashotah Lake drainage basin include a capital cost over the period of 1975-2000 of $63,000, an average annual operation and maintenance cost of $1,200, and a total 50-year present worth cost of $75,900.*

[d] *Cost estimated to control erosion from the estimated 10.3 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

[e] *Cost estimated to harvest macrophytes from the 20 acres of Upper Nashotah Lake subject to excessive macrophyte growth.*

[f] *Cost estimated to aerate the entire hypolimnion of the lake.*

[g] *The lower cost for nutrient inactivation is for treating only the hypolimnetic area with alum; the higher cost is for treating the entire lake with alum.*

[h] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[i] *The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*Source: SEWRPC*

further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-279 may include hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Upper Nashotah Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Upper Nashotah Lake would entail a total capital cost of about $484,900, and an average annual operation and maintenance cost of $8,100. The total 50-year present worth cost of these source control measures is $477,400, with an equivalent annual cost of $30,400. If, in addition, rehabilitation techniques are found necessary, the capital cost of these inactivation would range from $7,000 for nutrient inactivating to $266,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $5,200 for nutrient inactivation to $198,800 for sediment covering.

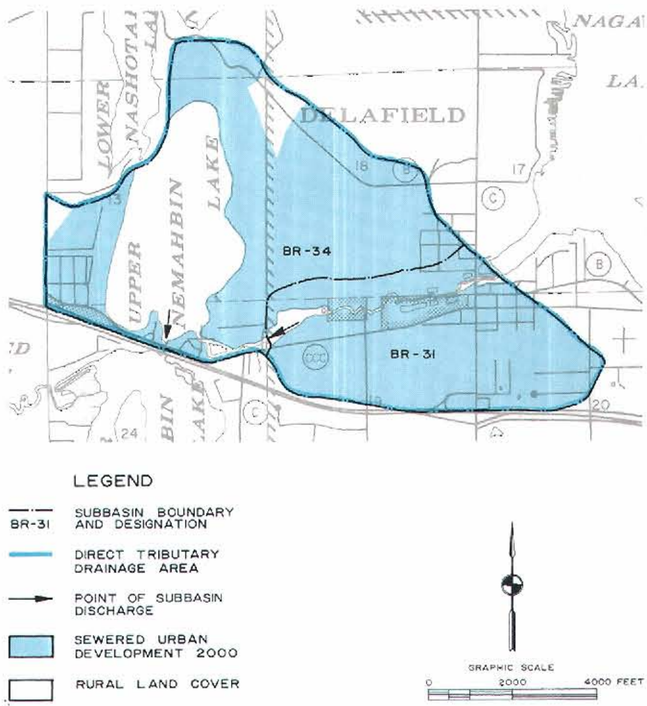
Upper Nemahbin Lake

Upper Nemahbin Lake is a 283-acre lake located in the Town of Summit in Waukesha County. The lake drains to the Bark River via Lower Nemahbin Lake. Certain geomorphological characteristics of Upper Nemahbin Lake are set forth in Table C-2807, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-94 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-94, all of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 281 privately owned onsite sewage disposal systems—86 located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the watershed area.

As indicated in Table C-281, all direct sources combined contribute about 1,500 pounds of phosphorus annually to Upper Nemahbin Lake. The major source of direct phosphorus in the lake watershed is livestock operations. An additional 10,000 pounds of phosphorus are contributed annually as inflow from Lower Nashotah and Nagawicka Lakes. Also, as indicated in Table C-281, urban land uses in the watershed are expected to increase by about 90 percent under planned year 2000 land cover

Map C-94

PLANNED LAND COVER DEVELOPMENT IN THE DIRECT TRIBUTARY DRAINAGE AREA OF UPPER NEMAHBIN LAKE: 2000




Upper Nemahbin Lake has a direct tributary drainage area of about 1,208 acres. About 102 acres, or 8 percent of the drainage area, are planned to be in rural land cover, and 1,106 acres, or 92 percent, to be in urban land cover. Over the planning period an average of about 36 acres may be expected to be converted annually to urban land cover. It is estimated that a 60 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. A combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and construction erosion controls—should be implemented in the lake drainage area.

*Source: SEWRPC.*

Table C-280

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF UPPER NEMAHBIN LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 283 acres |
| Direct Tributary Drainage Area | 1,208 acres |
| Shoreline | 2.90 miles |
| Depth | |
| Maximum | 60 feet |
| Mean | 29.6 feet |
| Volume | 8,377 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 698 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; excessive macrophyte growth; occasional lack of oxygen in the hypolimnion |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.2 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-281

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO UPPER NEMAHBIN LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 564 | 128 | 8.5 | 1,070 | 186 | 6.5 |
| Land under Development–Construction Activities (acres) | – | – | – | 36 | 1,618 | 56.2 |
| Onsite Sewage Disposal Septic Tank Systems[b] | 86 | 249 | 16.5 | – | – | – |
| Rural Land Cover (acres) | 644 | 63 | 4.2 | 102 | 10 | 0.3 |
| Livestock Operations (animal units) | 140 | 924 | 61.4 | 140 | 924 | 32.1 |
| Atmospheric Contribution (acres of receiving surface water) | 283 | 142 | 9.4 | 283 | 142 | 4.9 |
| Total | – | 1,506[c] | 100.0 | – | 2,880[c] | 100.0 |

[a] *Assumes provision of sanitary sewer service as recommended in the point source pollution abatement plan element; assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated phosphorus load of 10,000 pounds per year or the year 2000 anticipated phosphorus load of 3,100 pounds per year contributed by the drainage from Lower Nashotah and Nagawicka Lakes.*

*Source: SEWRPC.*

conditions, with annual total direct phosphorus loadings to the lake expected to be increased to about 2,900 pounds as a result of the increased urbanization. Loadings from the construction activities needed for the development of urban land are expected to be the primary direct source of phosphorus to the lake under anticipated year 2000 conditions. Loadings from Lower Nashotah and Nagawicka Lakes are expected to be reduced to about 3,100 pounds of phosphorus annually as a result of lake management practices recommended for those watersheds. The estimated total phosphorus concentrations during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, are 0.10 milligram per liter (mg/l) and 0.05 mg/l, respectively. The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and for the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Upper Nemahbin Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-282, along with the associated costs and anticipated effectiveness. Measures to control livestock contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: the provision of sanitary sewer service, minimum measures to reduce pollutant runoff from rural

**Table C-282**

**WATER QUALITY MANAGEMENT MEASURES FOR UPPER NEMAHBIN LAKE IN WAUKESHA COUNTY**

| | Estimated Cost 1980-2000 | | Economic Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Present Worth: 1975-2025 | | | Equivalent Annual: 1975-2025 | | | | Cumulative Reduction in External Annual Phosphorus Load to Lake[a] (percent) |
| Management Measure | Total Capital | Average Annual Operation and Maintenance | Capital | Operation and Maintenance | Total | Capital | Operation and Maintenance | Total | Anticipated Effectiveness | |
| Sanitary Sewer Service[b] | – | – | – | – | – | – | – | – | Protect public health and drinking water supplies; reduce nutrient concentrations | – |
| Livestock Waste Control | $ 12,300 | $ 1,100 | $ 9,200 | $ 12,400 | $ 21,600 | $ 600 | $ 800 | $ 1,400 | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 60[i] |
| Minimum Rural Conservation Practices | 100 | 700 | 100 | 9,100 | 9,200 | Minimal | 600 | 600 | | |
| Construction Erosion Control Practices[c] | 1,663,200 | 14,400 | 1,248,300 | 227,000 | 1,475,300 | 79,200 | 14,400 | 93,600 | | |
| Low Cost Urban Land Management Practices | Minimal | 1,300 | Minimal | 18,600 | 18,600 | Minimal | 1,200 | 1,200 | | |
| Total | 1,675,600 | 17,500 | 1,257,600 | 267,100 | 1,524,700 | 79,800 | 17,000 | 96,800 | | |
| Macrophyte Harvesting[d] | 37,300 | 5,200 | 27,900 | 82,000 | 109,900 | 1,800 | 5,200 | 7,000 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[e] | 34,000 | 900 | 25,400 | 13,400 | 38,800 | 1,600 | 900 | 2,500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[f] | 28,300 | – | 21,100 | – | 21,100 | 1,300 | – | 1,300 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[g,h] | 566,000 | – | 423,000 | – | 423,000 | 26,800 | – | 26,800 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |

*a The cumulative percent reduction in phosphorus loadings is in addition to sanitary sewer service, as recommended in the point source element for the Middle Rock River subregional area.*

*b Sanitary sewerage system costs for treatment facilities and major trunk sewers are included under the point source alternative plan elements for the Middle Rock River subregional area. Local hook-up and operation and maintenance costs, which are not primarily dependent on surface water quality, are not presented above. The estimated expenditures for local hook-up and operation and maintenance in the Upper Nemahbin Lake drainage basin include a capital cost over the period of 1975-2000 of $2,044,000, an average annual operation and maintenance cost of $15,300, and a total 50-year present worth cost of $1,386,900.*

*c Cost estimated to control erosion from the estimated 36 acres of land estimated to be annually undergoing construction activity in the lake watershed.*

*d Cost estimated to harvest macrophytes from the 40 acres of Upper Nemahbin Lake subject to excessive macrophyte growth.*

*e Cost estimated to aerate the entire hypolimnion of the lake.*

*f The cost for nutrient inactivation is for treating the entire lake with alum.*

*g Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

*h The costs for sediment covering vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled.*

*i The reduction in the direct phosphorus load to Upper Nemahbin Lake must be augmented by the implementation of minimum practices in the upstream drainage area of the Bark River if the total lake load is to be reduced to acceptable levels. Therefore, the nonpoint souce plan element must be implemented if Upper Nemahbin Lake is to meet the water quality criteria for recreation and a warmwater fishery.*

*Source: SEWRPC.*

lands through the implementation of basic soil conservation practices, low-cost measures to reduce pollutant runoff from urban lands, and construction erosion control practices.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-282 include hypolimnetic aeration, sediment covering, and nutrient inactivation. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Upper Nemahbin Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Upper Nemahbin Lake would entail a total capital cost of about $1,675,600, and an average annual operation and maintenance cost of about $17,500. The total 50-year present worth cost of these source control measures is $1,524,700, with an equivalent annual cost of $96,800. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $28,300 for nutrient inactivation to $566,000 for sediment covering. The total present worth costs of these lake rehabilitation techniques would range from $21,100 for nutrient inactivation to $423,000 for sediment covering.

Waterville Pond

Waterville Pond is a 68-acre lake located in the Town of Summit in Waukesha County. The lake drains to Scuppernong Creek. Certain geomorphological characteristics of Waterville Pond are set forth in Table C-283, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-95 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-95, only a very small portion of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 47 privately owned onsite sewage disposal systems—18 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-284, all direct tributary sources combined contribute about 800 pounds of phosphorus annually to Waterville Pond. The major source of phosphorus in the lake watershed is livestock operations. An

**Table C-283**

**GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF WATERVILLE POND**

| Characteristic | Description |
|---|---|
| Surface Area | 68 acres |
| Direct Tributary Drainage Area | 1,357 acres |
| Shoreline | 1.87 miles |
| Depth | |
| Maximum | 12.0 feet |
| Mean | 4.0 feet |
| Volume | 274 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 150 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; some macrophyte growth; high nutrient concentrations; potential for winter fishkill |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.20 persons per dwelling unit as counted on 1″ = 400′ scale aerial photos.*

*Source: SEWRPC.*

**Table C-284**

**ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO WATERVILLE POND: 1975 and 2000**

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 188 | 31 | 3.8 | 188 | 31 | 3.8 |
| Land under Development–Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 18 | 52 | 6.3 | 18 | 52 | 6.3 |
| Rural Land Cover (acres) | 1,169 | 179 | 21.7 | 1,169 | 179 | 21.7 |
| Livestock Operations (animal units) | 80 | 528 | 64.1 | 80 | 528 | 64.1 |
| Atmospheric Contribution (acres of receiving surface water) | 68 | 34 | 4.1 | 68 | 34 | 4.1 |
| Total | – | 824[c] | 100.0 | – | 824[c] | 100.0 |

[a] *Assumes no nonpoint source control.*

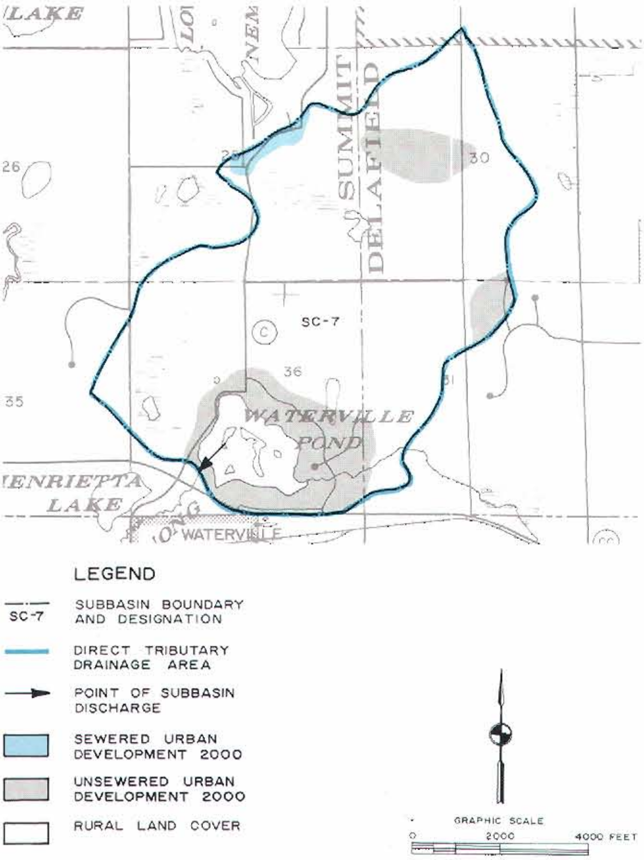
[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

[c] *Does not include the 1975 estimated and year 2000 anticipated phosphorus load of 480 pounds per year contributed by the upstream portion of Scuppernong Creek.*

*Source: SEWRPC.*

Map C-95

PLANNED LAND COVER DEVELOPMENT
IN THE DIRECT TRIBUTARY DRAINAGE
AREA OF WATERVILLE POND: 2000




Waterville Pond has a direct tributary drainage area of about 1,357 acres. About 1,169 acres, or 86 percent of the drainage area, are planned to be in rural land cover, and 188 acres, or 14 percent, to be in urban land cover. Over the planning period essentially none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of minimum rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

additional 480 pounds of phosphorus enter the lake annually with runoff from upstream portions of Scuppernong Creek. Also, as indicated in Table C-284, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.04 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Waterville Pond which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with attendant costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-285, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands. A small portion of the northern lake watershed is proposed to be sewered in year 2000, however, the lakeshore is unaffected by this proposal. Implementation of these measures must be supplemented by those minimum measures recommended in the nonpoint source plan element for that portion of the Rock River watershed tributary to Waterville Pond in order for the total phosphorus loadings to the lake to be reduced to the desired level.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned point and nonpoint source controls. Alternative restoration measures as set forth in Table C-285 may include aeration, sediment covering, or dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance

## Table C-285

## WATER QUALITY MANAGEMENT MEASURES FOR WATERVILLE POND IN WAUKESHA COUNTY

| Management Measure | Estimated Cost 1980-2000: Total Capital | Estimated Cost 1980-2000: Average Annual Operation and Maintenance | Economic Analysis — Present Worth: 1975-2025: Capital | Present Worth: Operation and Maintenance | Present Worth: Total | Equivalent Annual: 1975-2025: Capital | Equivalent Annual: Operation and Maintenance | Equivalent Annual: Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | – | – | – | – | – | – | – | – | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | |
| Livestock Waste Control | $ 17,100 | $ 1,300 | $ 12,800 | $ 15,000 | $ 27,800 | $ 800 | $ 1,000 | $ 1,800 | | |
| Minimum Rural Conservation Practices | 200 | 2,000 | 200 | 25,000 | 25,200 | Minimal | 1,600 | 1,600 | | |
| Low Cost Urban Land Management Practices | Minimal | 300 | Minimal | 4,600 | 4,600 | Minimal | 300 | 300 | | 75[g] |
| Total | 17,300 | 3,600 | 13,000 | 44,600 | 57,600 | 800 | 2,900 | 3,700 | | |
| Macrophyte Harvesting[b] | 6,500 | 900 | 4,900 | 14,300 | 19,200 | 300 | 900 | 1,200 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Aeration[c] | 4,000 | 100 | 3,000 | 1,600 | 4,600 | 200 | 100 | 300 | Prevent anaerobic conditions from occurring | No additional reduction |
| Sediment Covering[d,f] | 136,800 | – | 102,200 | – | 102,200 | 6,500 | – | 6,500 | Accelerate pond improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[e,f] | 1,213,600 | – | 906,900 | – | 906,900 | 57,500 | – | 57,500 | Deepen pond; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Waterville Pond. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Waterville Pond drainage basin include a capital cost over the period of 1975-2000 of $81,000, an average annual operation and maintenance cost of $1,600, and a total 50-year present worth cost of $99,600.*

[b] *Cost estimated to harvest macrophytes from the 7 acres of Waterville Pond subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate 20 acres of the pond.*

[d] *Cost estimated to cover the entire pond bottom with sand, clay, plastic, or other suitable material.*

[e] *Cost estimated to dredge pond to an average depth of 15 feet. Existing average depth is 4 feet.*

[f] *The costs for sediment covering and dredging vary widely depending on such factors as pond size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

[g] *The reduction in the direct phosphorus load to Waterville Pond must be augmented by the implementation of minimal practices in the upstream drainage area of the Scuppernong Creek if the total pond load is to be reduced to acceptable levels. Therefore, the nonpoint source plan element must be implemented if Waterville Pond is to meet the water quality criteria for recreation and a warmwater fishery.*

*Source: SEWRPC.*

of water quality in Waterville Pond requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Waterville Pond would entail a total capital cost of about $17,300, and an average annual operation and maintenance cost of about $3,600. The total 50-year present worth of these source control measures is $57,600, with an equivalent annual cost of $3,700. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $4,000 for aeration to $1,213,600 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $4,600 for surface aeration to $906,900 for dredging.

Whitewater Lake

Whitewater Lake is a 640-acre lake located in the Town of Whitewater in Walworth County. The lake drains to Whitewater Creek via Rice Lake. Certain geomorphological characteristics of Whitewater Lake are set forth in Table C-286, together with the approximate 1975 population of the direct tributary watershed and a brief description of lake water quality conditions. Map C-96 presents a graphic summary of the proposed year 2000 land cover in the lake watershed. As shown on Map C-96, none of the urban land in the tributary watershed area is proposed to be served by sanitary sewers by the year 2000. As of 1975, an estimated 406 privately owned onsite sewage disposal systems—300 of which were located in areas covered by soils having severe or very severe limitations for the use of such systems—were in operation in the lake watershed area.

As indicated in Table C-287, all sources combined contribute about 4,500 pounds of phosphorus annually to Whitewater Lake. The major source of phosphorus in the lake watershed is livestock operations. Also, as indicated in Table C-287, land uses and phosphorus loads in the watershed are not expected to change significantly under planned year 2000 land cover conditions. The estimated total phosphorus concentration during spring overturn under existing and anticipated year 2000 conditions, as estimated from phosphorus loadings and lake and drainage basin characteristics, is 0.10 milligram per liter (mg/l). The Commission recommends a level of 0.02 mg/l or less of total phosphorus for the prevention of excessive aquatic plant growth and the maintenance of a warmwater fishery and recreational use classification. Existing and anticipated year 2000 pollutant loadings may be expected to result in total phosphorus concentrations in Whitewater Lake which exceed the recommended level for recreational use and for the maintenance of a warmwater fishery.

The measures available for controlling nonpoint source pollution, along with anticipated costs, are discussed in the introductory sections of Chapter IV of this volume. An evaluation of these measures, applied in alternative combinations to reduce the nonpoint source pollution loading on the lake, was made and a set of recommended measures was identified. These measures are set forth in Table C-288, along with the associated costs and anticipated effectiveness. Measures to control livestock waste contributions appear to be the most cost-effective way to substantially reduce phosphorus loadings to the lake. Other needed measures include: improved septic tank system management, minimum measures to reduce pollutant runoff from rural lands through the implementation of basic soil conservation practices, and low-cost measures to reduce pollutant runoff from urban lands.

If nutrient loadings to the lake are reduced by the actions noted above, the sediments which have been deposited on the lake bottom may provide a suitable bottom substrate and nutrient source for excessive macrophyte growth in some local areas and may release nutrients to the water body. If this problem is confirmed through further local study, the application of lake restoration or rehabilitation procedures should be considered, in addition to the above-mentioned nonpoint source controls. Alternative restoration measures as set forth in Table C-288 may include nutrient inactivation, hypolimnetic aeration, sediment covering, and dredging. The feasibility of these measures would have to be assessed in a preliminary engineering study. Additional management measures such as weed harvesting may be used to control the macrophyte growth which may interfere with the recreational use of the lake. It should be emphasized, however, that the long-term maintenance of water quality in Whitewater Lake requires that the recommended level of nutrient input reductions be achieved.

The application of the above-listed nonpoint source pollution control measures to control the nutrient inputs to Whitewater Lake would entail a total capital cost of

Table C-286

GEOMORPHOLOGICAL AND WATER QUALITY CHARACTERISTICS OF WHITEWATER LAKE

| Characteristic | Description |
|---|---|
| Surface Area | 640 acres |
| Direct Tributary Drainage Area | 3,735 acres |
| Shoreline | 9.80 miles |
| Depth | |
| Maximum | 38.0 feet |
| Mean | 7.8 feet |
| Volume | 5,003 acre-feet |
| 1975 Population of Direct Tributary Watershed[a] | 1,271 persons |
| General Existing Water Quality Conditions: | Occasional algae blooms; some macrophyte growth; high nutrient concentrations |

[a] *The population of the direct tributary watershed is estimated by assuming an average of 3.3 persons per dwelling unit as counted on 1" = 400' scale aerial photos.*

*Source: SEWRPC.*

Table C-287

ESTIMATED DIRECT TRIBUTARY PHOSPHORUS LOADS TO WHITEWATER LAKE: 1975 and 2000

| Source of Phosphorus | Existing 1975 | | | Anticipated 2000[a] | | |
|---|---|---|---|---|---|---|
| | Number | Total Loading (pounds per year) | Percent Distribution | Number | Total Loading (pounds per year) | Percent Distribution |
| Urban Land Cover (acres) | 629 | 118 | 2.6 | 629 | 118 | 2.6 |
| Land under Development—Construction Activities (acres) | – | – | – | – | – | – |
| Onsite Sewage Disposal Septic Tank Systems[b] | 300 | 868 | 19.2 | 300 | 868 | 19.2 |
| Rural Land Cover (acres) | 3,106 | 330 | 7.3 | 3,106 | 330 | 7.3 |
| Livestock Operations (animal units) | 438 | 2,891 | 63.8 | 438 | 2,891 | 63.8 |
| Atmospheric Contribution (acres of receiving surface water) | 640 | 320 | 7.1 | 640 | 320 | 7.1 |
| Total | – | 4,527 | 100.0 | – | 4,527 | 100.0 |

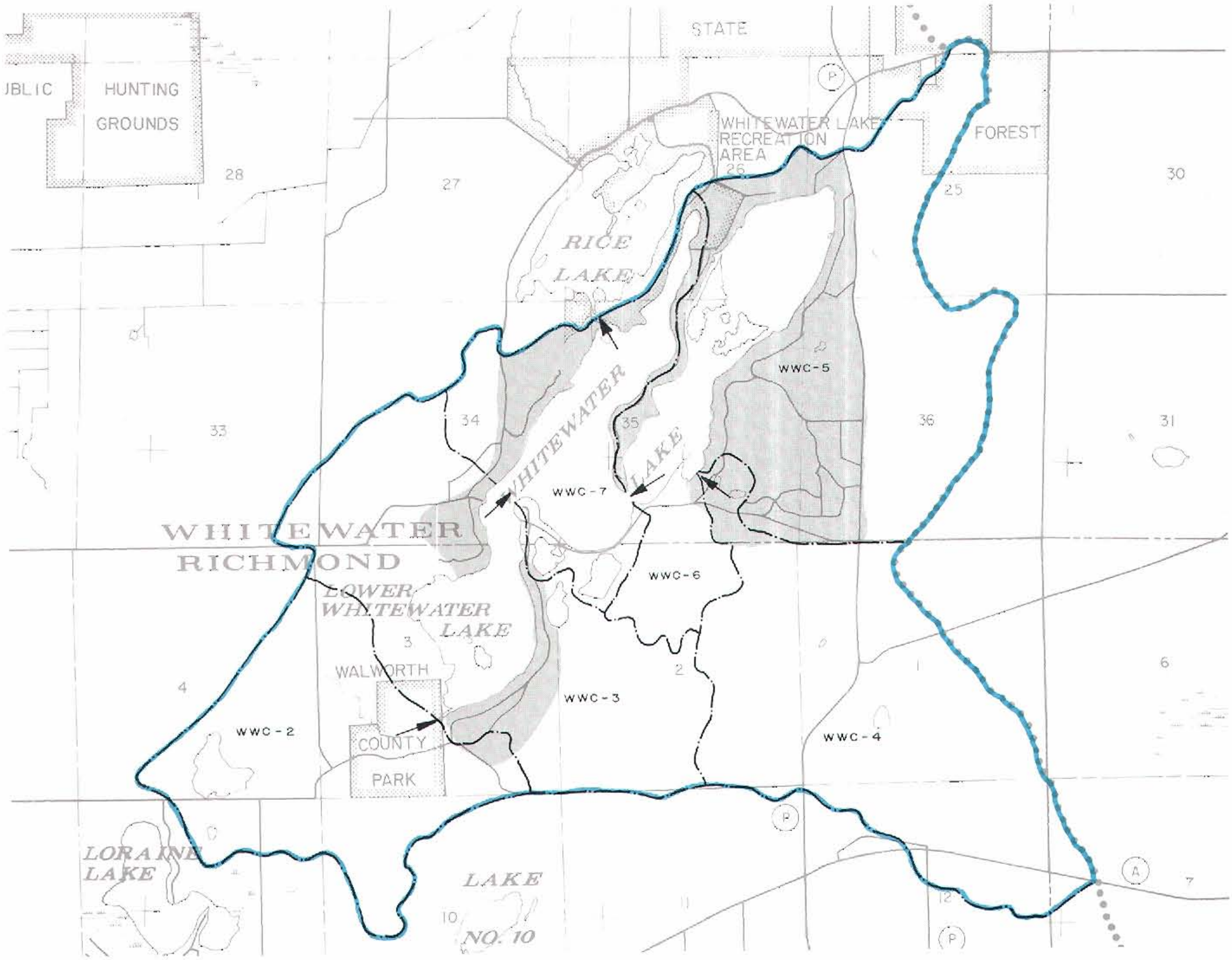
[a] *Assumes no nonpoint source control.*

[b] *Includes only those systems on soils having severe or very severe limitations for disposal of septic tank effluent.*

*Source: SEWRPC.*

Map C-96

## PLANNED LAND COVER IN THE DIRECT TRIBUTARY DRAINAGE AREA OF WHITEWATER LAKE: 2000




LEGEND

- WATERSHED BOUNDARY
- SUBBASIN BOUNDARY AND DESIGNATION (WWC-2)
- DIRECT TRIBUTARY DISCHARGE AREA
- POINT OF SUBBASIN DISCHARGE
- UNSEWERED URBAN DEVELOPMENT 2000
- RURAL LAND COVER

GRAPHIC SCALE
0 2000 4000 FEET

Whitewater Lake has a direct tributary drainage area of about 3,735 acres. About 3,106 acres, or 83 percent of the drainage area, are planned to be in rural land cover, and 629 acres, or 17 percent, to be in urban land cover. Over the planning period none of the direct tributary watershed area is expected to be converted to urban land cover. It is estimated that an 80 percent reduction in nonpoint source pollutant runoff will be required in the drainage area to protect the water quality of the lake. This can be achieved through a combination of rural land management practices—including especially the proper management of livestock wastes—and minimum urban management practices—including low-cost urban practices and proper septic tank system management based on a site-by-site inspection and maintenance program.

*Source: SEWRPC.*

Table C-288

## WATER QUALITY MANAGEMENT MEASURES FOR WHITEWATER LAKE IN WALWORTH COUNTY

| Management Measure | Estimated Cost 1980-2000 Total Capital | Estimated Cost 1980-2000 Average Annual Operation and Maintenance | Economic Analysis Present Worth: 1975-2025 Capital | Present Worth: 1975-2025 Operation and Maintenance | Present Worth: 1975-2025 Total | Equivalent Annual: 1975-2025 Capital | Equivalent Annual: 1975-2025 Operation and Maintenance | Equivalent Annual: 1975-2025 Total | Anticipated Effectiveness | Cumulative Reduction in External Annual Phosphorus Load to Lake (percent) |
|---|---|---|---|---|---|---|---|---|---|---|
| Septic Tank System Management[a] | -- | -- | -- | -- | -- | -- | -- | -- | Reduce nutrient concentrations; prevent the stimulation of excessive macrophyte and algae growth; improve recreational use potential | 80 |
| Livestock Waste Control | $ 38,500 | $ 3,300 | $ 28,800 | $ 38,700 | $ 67,500 | $ 1,800 | $ 2,500 | $ 4,300 | | |
| Minimum Rural Conservation Practices | 700 | 5,600 | 500 | 68,500 | 69,000 | 100 | 4,300 | 4,400 | | |
| Low Cost Urban Land Management Practices | Minimal | 900 | Minimal | 12,800 | 12,800 | Minimal | 800 | 800 | | |
| Total | 39,200 | 9,800 | 29,300 | 120,000 | 149,300 | 1,900 | 7,600 | 9,500 | | |
| Macrophyte Harvesting[b] | 59,600 | 8,300 | 44,500 | 130,800 | 175,300 | 2,800 | 8,300 | 11,100 | Control excessive macrophyte growth; aesthetic enhancement; improve recreational use potential | Minimal additional reduction |
| Hypolimnetic Aeration[c] | 6,400 | 200 | 4,800 | 3,200 | 8,000 | 300 | 200 | 500 | Prevent anaerobic conditions (lack of oxygen) in the hypolimnion | No additional reduction |
| Nutrient Inactivation[d] | 64,000 | -- | 47,800 | -- | 47,800 | 3,000 | -- | 3,000 | Accelerate lake improvement; prevent release of nutrients from sediment; remove nutrients from water body | No additional reduction |
| Sediment Covering[e,g] | 1,280,000 | -- | 956,500 | -- | 956,500 | 60,700 | -- | 60,700 | Accelerate lake improvement; prevent release of nutrients from sediment; reduce suitable plant substrate | No additional reduction |
| Dredging[f,g] | 7,432,700 | -- | 5,554,500 | -- | 5,554,500 | 352,400 | -- | 352,400 | Deepen lake; reduce macrophyte growth | No additional reduction |

[a] *The proper maintenance and replacement of the remaining septic tank systems is recommended to help improve the water quality of Whitewater Lake. However, because septic tank systems management is an existing function necessary for the preservation of public health and the maintenance of drinking water supplies, this cost is not included in the water quality management plan. The estimated expenditures for septic system management in the Whitewater Lake drainage basin include a capital cost over the period of 1975-2000 of $1,350,000, an average annual operation and maintenance cost of $15,200, and a total 50-year present worth cost of $1,283,500.*

[b] *Cost estimated to harvest macrophytes from the 64 acres of Whitewater Lake subject to excessive macrophyte growth.*

[c] *Cost estimated to aerate the entire hypolimnion of the lake.*

[d] *The cost for nutrient inactivation is for treating the entire lake with alum.*

[e] *Cost estimated to cover the entire lake bottom with sand, clay, plastic, or other suitable material.*

[f] *Cost estimated to dredge lake to an average depth of 15 feet. Existing average depth is 7.8 feet.*

[g] *The costs for sediment covering and dredging vary widely depending on such factors as lake size and depth, type of bottom substrate, and amount of material to be filled or dredged.*

*Source: SEWRPC*

about $39,200, and an average annual operation and maintenance cost of about $9,800. The total 50-year present worth cost of these source control measures is $149,300, with an equivalent annual cost of $9,500. If, in addition, rehabilitation techniques are found necessary, the capital cost of these alternatives would range from $64,000 for nutrient inactivation to $7,432,700 for dredging. The total present worth costs of these lake rehabilitation techniques would range from $47,800 for nutrient inactivation to $5,554,500 for dredging.