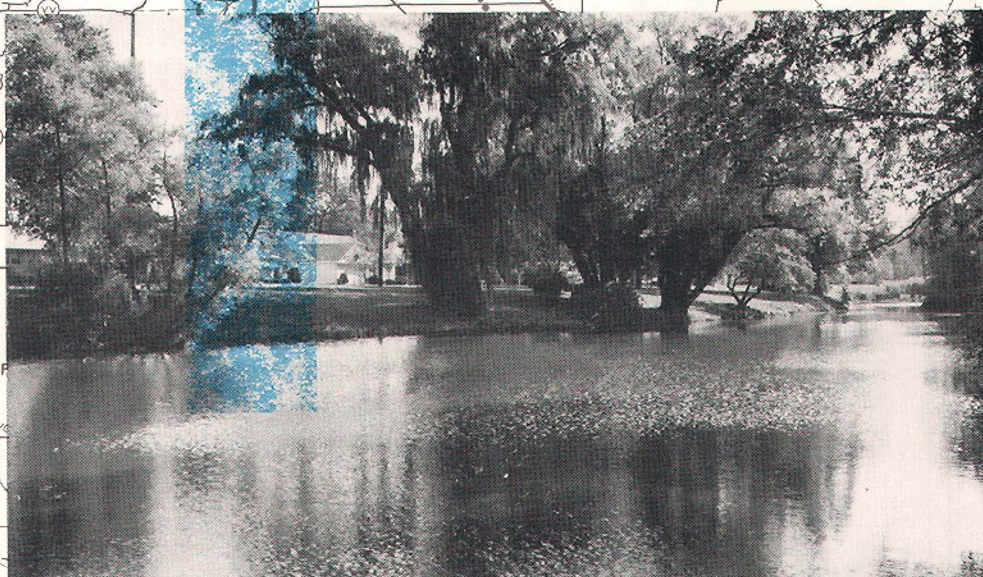
PLANNING REPORT NO. 26

A COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED



volume two

ALTERNATIVE PLANS AND RECOMMENDED PLAN

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Planning Report Number 26

A COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED

Volume Two

ALTERNATIVE PLANS AND RECOMMENDED PLAN

Prepared by the
Southeastern Wisconsin Regional Planning Commission

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STATEMENT OF THE CHAIRMAN

This report is the second of two volumes documenting the findings and recommendations of a four-year study of the serious and costly flooding, water pollution, and related land use problems existing in the Menomonee River watershed in southeastern Wisconsin. The study was undertaken by the Commission in response to formal requests by the Common Councils of the Cities of Brookfield and Wauwatosa and the Milwaukee County Board of Supervisors. The study, which was guided by a 15-member Menomonee River Watershed Committee, was designed to prepare a comprehensive plan for the development of the watershed, which plan could assist the local, state, and federal units and agencies of government concerned in solving the flooding, water pollution, and related land use problems of the watershed.

The first volume, being published simultaneously with this volume, presents a summary of the factual findings of the planning and engineering inventories conducted under the study; identifies and, to the extent possible, quantifies the land and water resource-related problems of the watershed; and presents pertinent forecasts of anticipated growth and change within the watershed. The inventories and forecasts set forth in the first volume provide the basis for the preparation of alternative watershed plans and for the selection of a recommended plan from among these alternatives.

This second and final volume of the planning report sets forth watershed development objectives, principles, and standards; presents and comparatively evaluates the alternative land use, natural resource protection, parkway-scenic drive-recreational trail, flood control, and water quality management plan elements considered; describes the preliminary recommended comprehensive plan for the watershed as that plan was presented at a series of public informational meetings and hearings; describes the recommended comprehensive plan for the watershed as revised after the public meetings and hearings; and sets forth detailed recommendations on the means for carrying out that recommended plan.

The recommended watershed plan set forth in this volume represents another important element in the evolving comprehensive plan for the physical development of the Southeastern Wisconsin Region. As is true of all of the Commission's work, the Menomonee River watershed plan is entirely advisory to the local, state, and federal units and agencies of government concerned. The recommended plan elements and the implementation proposals set forth in this report are intended to provide a point of departure against which watershed development proposals can be evaluated as they arise on a day-to-day basis. Upon formal adoption of the final watershed plan by the Commission, an official copy thereof will be transmitted to all affected units and agencies of government with a request for their consideration and formal adoption or endorsement and appropriate implementing action. Plan implementation must necessarily be achieved through the cooperative action of all of the governmental units and agencies operating within the watershed.

In its continuing role of acting as a center for the coordination of planning activities within the Region, the Commission stands ready to provide such assistance as may be requested of it to the various units and agencies of government concerned in implementation of the Menomonee River watershed plan.

Respectfully submitted,

George C. Berteau
Chairman

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Chapter I

INTRODUCTION

This chapter begins the second of two volumes, which together present the major findings and recommendations of the Southeastern Wisconsin Regional Planning Commission Menomonee River watershed planning program. The first volume sets forth the basic principles and concepts underlying the study and presents in summary form the basic facts pertinent to the preparation of a comprehensive plan for the physical development of the Menomonee River watershed, with particular emphasis upon the existing state of the land and water resources of the basin and the developmental and environmental problems associated with these resources. The first volume also contains forecasts of anticipated future growth and change within the watershed and an analysis of water law, as such law relates to watershed plan preparation and implementation, with particular emphasis upon floodland management and pollution abatement.

This, the second volume of the series, sets forth watershed development objectives, principles, and standards; presents alternative plans for land use and water control facility development and for resource preservation and enhancement within the watershed; and recommends a comprehensive plan designed to meet the watershed development objectives under existing and probable future conditions. It proposes a staged development of needed water control facilities and recommends means for plan implementation. In addition, this volume also presents a comparative analysis of the changes which may be expected to occur within the watershed over the next two to three decades if present development trends continue without redirection in the public interest. This latter alternative is presented not as a plan to be used to guide development within the watershed, but, rather, as a forecast of unplanned development and is intended to be used as a standard of comparison for the evaluation of the recommended watershed development plan.

The recommended watershed development plan presented in this volume is the end result of a seven-step planning process developed by the Commission under which the principal functional relationships existing within the watershed can be accurately described, both graphically and numerically; and the effect of different courses of action with respect to land use and water control facility development can be evaluated. The seven steps involved in this planning process are: 1) study design, 2) formulation of objectives and standards, 3) inventory, 4) analysis and forecast, 5) plan design, 6) plan test and evaluation, and 7) plan selection and adoption. Volume 1 of this report dealt with the first, third, and fourth steps in this planning process. This volume deals with the remaining four steps: formulation of objectives and standards, plan design, plan test and evaluation, and plan selection and adoption. Plan implementation, although beyond the initial planning process, has been considered throughout the process; and this volume contains specific recommendations for plan implementation.

A brief description of each of the seven steps comprising the planning process is contained in Chapter II, Volume 1, of this report, together with a statement of the basic principles and concepts underlying the watershed planning process and a discussion of the watershed as a rational planning unit. Reconsideration of, and elaboration on, the four steps in the planning process with which this volume is concerned is warranted here.

FORMULATION OF OBJECTIVES AND STANDARDS

It was noted in Volume 1 of this report that planning is a rational process for formulating and meeting objectives; and, 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 task of formulating objectives and the consequent inherent difficulty of resolving the problem of objectives are not sufficient reasons for neglecting 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, in part, the absence of a clearcut basis for a choice between value systems and, in part, it reflects 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 there may be no single argument to support the given choice of objectives, because of differing value systems, 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 the objectives, as well as of the underlying value systems. Even so, it must be recognized that objectives may change as a selection is attempted from among alternative means or plans. 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. The 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 watershed development objectives, like regional development objectives, should incorporate the combined knowledge of many people who are informed about the watershed. These watershed development objectives, further, 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 watershed planning studies, 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 procedure available for involving officials, professionals, technicians, and citizens in the regional planning process and of openly arriving at decisions and action programs which can shape the future physical development of the Region and its component watersheds. Only by combining the accumulated knowledge and experience which the various advisory committee members possess can a meaningful expression of desired direction, magnitude, and quality of future regional and watershed development 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 watershed planning objectives, principles, and standards which have been adopted by the Commission after careful review and recommendation by the advisory committees concerned.

PLAN DESIGN

It was noted in Volume 1 of this report that plan synthesis, or design, forms the heart of the planning process and that the watershed plan design problem consists essentially of determining the allocation of scarce resources—land and water—between competing and often conflicting demands. This allocation must be accomplished so as to satisfy the aggregate needs for each use and comply with the design standards derived from the plan objectives, all at a feasible cost.

The task of designing two of the major components of the physical system which comprises a watershed —the land use pattern and the water control facilities— is a complex and difficult problem. Not only does each component constitute in itself a major problem in terms of the sheer size of the system to be designed, but the pattern of interaction between the components is also exceedingly complex and dynamic. The land use pattern must enable people to live in close cooperation and yet freely pursue an enormous variety of interests. It must minimize conflicts between population growth and limited land and water resources; maintain an ecological balance of human, animal, and plant life; and avoid gross public health and welfare problems. The water control facilities must be able to carry the flood and pollution loadings generated by the land use pattern, meeting 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 Menomonee River watershed study. These means center primarily on the application of systems engineering techniques to the quantitative test of both the land use and water facility plans, as described below under the plan test and evaluation phase. Yet the quantitative tests involved in these techniques, while powerful aids to the determination of the adequacy of the plan design, are of strictly limited usefulness in actual plan synthesis. Consequently, it is still necessary to develop both the land use and water facility plans by traditional intuitional "cut-and-try" methods, to quantitatively test the resulting design by application of simulation techniques where applicable, and 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 land use and water facility plan syntheses, the Commission had at its disposal far more definitive information bearing on the problem than has ever before been available; and this fact alone has made the traditional plan synthesis techniques applied far more powerful and useful.

PLAN TEST AND EVALUATION

It was noted in Volume 1 of this report that, if the plans developed in the design stage of the planning process are to be practical and workable and thereby realized in terms of actual land use and water control facility system development, some techniques must be applied to quantitatively test the feasibility of alternative measure in advance of their adoption and implementation. As shown in Figure 1, 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.

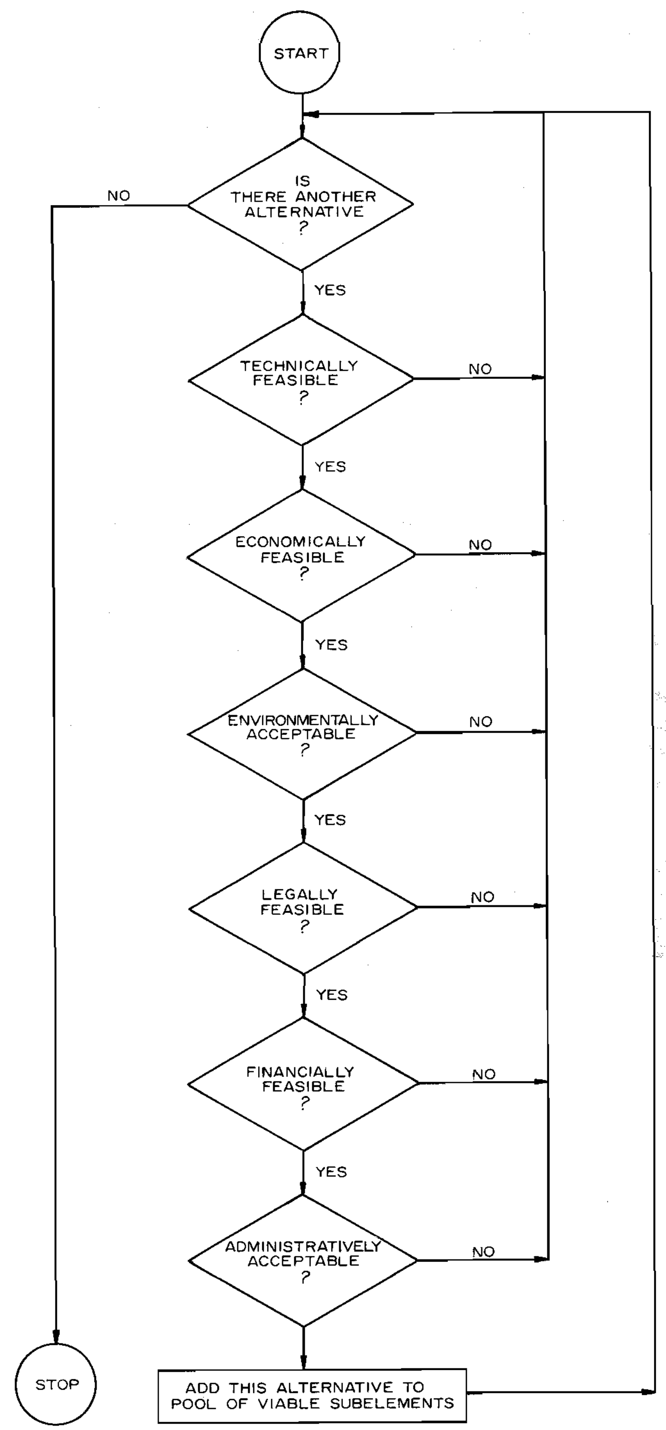
Devices used to test and evaluate alternative subelements range from mathematical models used to simulate river performance through interagency meetings and public hearings. To assist in a quantitative analysis of the engineering performance and the technical and economic feasibility of alternative plan elements, hydrologic, hydraulic, water quality, and flood economics models were developed and applied in the study. Test and evaluation, beyond the quantitative analyses permitted by the model application, involved qualitative evaluation of the degree to which each alternative land use or water control facility plan subelement met development objectives and standards and of the legal feasibility of the alternatives.

PLAN SELECTION AND ADOPTION

It also was noted in Volume 1 of this report that the general approach contemplated for the selection of one plan from among the considered alternatives was to proceed through the use of the Menomonee River Watershed Committee structure, through the interagency meetings and hearings to a final decision and plan adoption by the Commission in accordance with the provisions of State enabling legislation. Because plan selection and adoption necessarily involve both technical and nontechnical policy determinations, they must be founded in the active involvement throughout the entire planning process of the various governmental bodies, technical agencies, and private interest groups concerned with watershed development. Such involvement is particularly important in light of the advisory

Figure 1

TEST AND EVALUATION OF A PLAN SUBELEMENT



Source: SEWRPC.

role of the Commission in shaping regional development. The use of advisory committees and of both formal and informal hearings appears to be the most practical and effective procedure available for involving public officials, engineering and planning professionals, and citizens in the planning process and of openly arriving at agreement among the affected governmental bodies and agencies on objectives and on plans which can be jointly implemented.

The preparation of a recommended comprehensive plan for the Menomonee River watershed required that a selection be made from among the alternative elements including a land use base and necessary supporting water control and pollution abatement facilities. Together these should comprise the comprehensive plan. Such a selection must be based upon consideration of many tangible and intangible factors but should be focused primarily upon the degree to which the agreed-upon watershed development objectives are satisfied and upon the accompanying costs. Selection of the plan elements to be included in the final plan ultimately must be made by the responsible elected and appointed public officials concerned and not by the planning technicians, although the latter may properly make recommendations based upon evaluation of technical considerations.

As an integral part of the watershed planning program, a series of informal public informational meetings and a formal public hearing were held within the watershed. The dates and locations of these meetings and the hearing are set forth in Table 1. A summary of public reaction to the recommended plan and the SEWRPC staff and advisory committee reaction thereto is set forth in Chapter VI.

Table 1

SCHEDULE OF PUBLIC INFORMATIONAL MEETINGS AND PUBLIC HEARINGS ON THE COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED

Type of Meeting or Hearing	Presiding Agency	Place of Meeting	Date and Time of Meeting
Initial Public Hearing	Menomonee River Watershed Committee	Wauwatosa Memorial Civic Center	April 19, 1972 7:30 p.m. - 10:00 p.m.
Informational Meeting for Public Officials.	City of Brookfield	Brookfield City Hall	September 8, 1976 7:30 p.m. - 9:45 p.m.
Public Informational Meeting.	Menomonee River Watershed Committee	Menomonee Falls Village Hall	September 15, 1976 7:30 p.m. - 10:55 p.m.
Public Informational Meeting.	Menomonee River Watershed Committee	Wauwatosa Memorial Civic Center	September 16, 1976 7:30 p.m. - 10:55 p.m.
Final Public Hearing.	Menomonee River Watershed Committee	Wauwatosa Memorial Civic Center	September 22, 1976 7:30 p.m. - 10:55 p.m.
Public Information Meeting.	City of Mequon	Mequon City Hall	September 30, 1976 7:30 p.m. - 10:15 p.m.

Source: SEWRPC.

Chapter II

WATERSHED DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS

INTRODUCTION

As noted in Chapter II of Volume I of this report, the formulation of watershed development objectives and supporting standards is the second step in the SEWRPC seven-step watershed planning process. The formulation of objectives is, therefore, an essential task which must be undertaken relatively early in the planning process before a comprehensive watershed plan can be prepared.

The formulation of objectives for organizations whose functions are directed primarily at a single purpose or interest, such as a business corporation, is a relatively simple task. Many diverse and often divergent interests, however, are concerned about the development of a watershed within an urbanizing region, such as the Menomonee River watershed, and consequently, the formulation of objectives for the preparation of a watershed development plan is a very complex and difficult task.

Soundly conceived watershed development objectives should incorporate the knowledge of many people who are informed not only about the watershed, but about the Region of which the watershed is an integral part. To the maximum extent possible, such objectives should be established by duly elected or appointed public officials legally assigned this task, assisted as necessary not only by planners and engineers but by interested and concerned citizen leaders as well. This is particularly important because of the value judgments inherent in any set of development objectives. The active participation of duly elected or appointed public officials, technicians, and citizen leaders in the overall regional planning program is implicit in the structure and organization of the Southeastern Wisconsin Regional Planning Commission itself. Moreover, the Commission very early in its existence recognized that the task of guiding the broad spectrum of related public and private development programs which would influence and be influenced by a comprehensive regional planning program would require the broadest possible opportunity for the active participation of public officials and private interest groups in the regional planning process. The Commission, accordingly, has provided for the establishment of a number of advisory committees to assist the Commission and its staff in the conduct of the regional planning program.

The Menomonee River Watershed Committee is only one of many advisory committees which have been created by the Commission to assist it in the formulation of development objectives and the preparation of regional plan elements directed toward the attainment of these objectives. Others include the Intergovernmental Coordinating Committee on Regional Land Use-Transportation Planning and the Technical Coordinating and Advisory Committee on Regional Land Use-Transportation Planning, which jointly contributed to the formulation of the land use and transportation development objectives adopted by the Commission; the Root, Fox, and Milwaukee River Watershed Committees, which contributed to the formulation of development objectives for these respective watersheds; the Technical Advisory Committee on Natural Resources and Environmental Design, which also contributed importantly to the formulation of all of the watershed development objectives; and the Technical Coordinating and Advisory Committee on Regional Sanitary Sewerage System Planning, which contributed to the formulation of sewerage system development objectives. Current membership on watershed and sanitary sewerage committees and on the Technical Advisory Committee on Natural Resources and Environmental Design totals over 140 knowledgeable elected and appointed public officials, technicians, and interested citizen leaders.

This chapter sets forth the regional land use and sanitary sewerage system planning objectives, principles, and standards which have been adopted by the Commission under related regional planning programs after careful review and recommendation by the advisory committees concerned and which are relevant to formulation of a comprehensive plan for the Menomonee River watershed. This chapter also presents a series of water control facility development objectives, principles, and standards formulated as a basis for the preparation of such a comprehensive plan.

In addition to presenting watershed development objectives, principles, and standards, this chapter discusses certain engineering design criteria and analytic procedures utilized in the Menomonee River watershed planning program to prepare and evaluate alternative plan subelements and to select and design the recommended watershed plan. These engineering design criteria and analytic procedures include important engineering techniques used to design alternative plan subelements, test the physical feasibility of those subelements, and make necessary economic comparisons between alternative plan subelements. The description of these criteria and procedures in this chapter is intended to document the degree of detail and level of sophistication employed in the preparation of the recommended watershed plan, and thereby to provide a better understanding by all concerned of the plan and of the need for refinements of some aspects of that plan prior to implementation.

It should be noted that, while the design criteria and analytic procedures as described herein were used in the preparation of the watershed plan, these criteria and procedures do not comprise standards as defined and discussed in this chapter. These criteria and procedures relate to the technical methods used in the inventory and analyses phases of the watershed study and in plan design, test, and evaluation, rather than to relating alternative plans to specific development objectives.

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 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 of 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.

WATERSHED DEVELOPMENT OBJECTIVES

Objectives, in order to be useful in the watershed planning process, must not only be logically sound and related in a demonstrable and measurable way to alternative physical development proposals, but must also be consistent with, and grow out of, regionwide development objectives. This is essential if the watershed plans are to comprise integral elements of a comprehensive plan for the physical development of the Region, and if sound coordination of regional and watershed development is to be achieved.

The Southeastern Wisconsin Regional Planning Commission has, in its planning efforts to date, adopted, after careful review and recommendation by various advisory and coordinating committees, nine general regional development objectives, nine specific regional land use development objectives, seven specific regional transportation system development objectives, four specific sanitary sewerage system development objectives, and four specific water control facility development objectives. These, together with their supporting principles and standards, are set forth in previous Commission planning reports. Certain of these objectives and supporting standards are directly applicable to the Menomonee River watershed planning effort, and are hereby recommended for adoption as development objectives for the Menomonee River watershed.

Land Use Development Objectives

Six of the nine specific regional land use development objectives adopted by the Commission under its regional land use-transportation planning program are directly applicable to the Menomonee River watershed planning effort.[1] 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 the protection, wise use, and development of the natural resources of the Region.

3. 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 economical provision of utility and municipal services.

4. The preservation and provision of open space to enhance the total quality of the regional environment, maximize essential natural resource availability, preserve and protect natural areas and wildlife habitat, give form and structure to urban development, and facilitate the ultimate attainment of a balanced year-round outdoor recreational program providing a full range of facilities for all age groups.

5. The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture, provide a reserve for future needs, and ensure the preservation of those rural areas which provide wildlife habitat and are essential to shape and order urban development.

6. The attainment of good soil and water conservation practices in order to reduce storm water runoff, soil erosion, and stream and lake sedimentation, pollution, and eutrophication.

[1] *The other three specific regional land use development objectives are: 1) a spatial distribution of the various land uses which will result in a compatible arrangement of land uses; 2) the development and conservation of residential areas within a physical environment that is healthy, safe, convenient, and attractive; and 3) the preservation and provision of a variety of suitable industrial and commercial sites both in terms of physical characteristics and location.*

Sanitary Sewerage System Planning Objectives

Three of the four specific sanitary sewerage system development objectives adopted by the Commission under its regional sanitary sewerage system planning effort are directly applicable to the Menomonee River watershed planning effort.[2] These are:

1. The development 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 sanitary waste disposal demand generated by the existing and proposed land uses.

2. The development of sanitary sewerage systems that are properly related to, and that will enhance the overall quality of, the natural and man-made environments.

3. The development of sanitary sewerage systems that are both economical and efficient, meeting all other objectives at the lowest cost possible.

Water Control Facility Development Objectives

Three of the four specific water control facility development objectives adopted by the Commission under its other comprehensive watershed planning programs are also applicable to the Menomonee River watershed planning effort.[3] These are:

1. An integrated system of drainage and flood control facilities and floodland management programs which will effectively reduce flood damage under the existing land use pattern of the watershed and promote the implementation of the watershed land use plan, meeting the anticipated runoff loadings generated by the existing and proposed land uses.

2. An integrated system of land management and water quality control facilities and pollution abatement devices adequate to ensure a quality of surface water necessary to meet the water uses shown on Map 1.

3. The attainment of sound groundwater resource development and protective practices to minimize the possibility for pollution and depletion of the groundwater resources.

[2] *The other specific sanitary sewerage system development objective is: The development of sanitary systems so as to meet established water use objectives and supporting water quality standards.*

[3] *The other specific water control facility development objective is: 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.*

Principles and Standards

Complementing each of the foregoing specific land use, water control facility, and sanitary sewerage system development objectives is a planning principle which supports the objective and asserts its inherent validity, and a set of quantifiable planning standards which can be used to evaluate the relative or absolute ability of alternative plan designs to meet the stated development objective. These principles and standards, as they apply to watershed planning and development, are set forth in Tables 2, 3, and 4, and serve to facilitate quantitative application of the objectives during plan design, test, and evaluation.

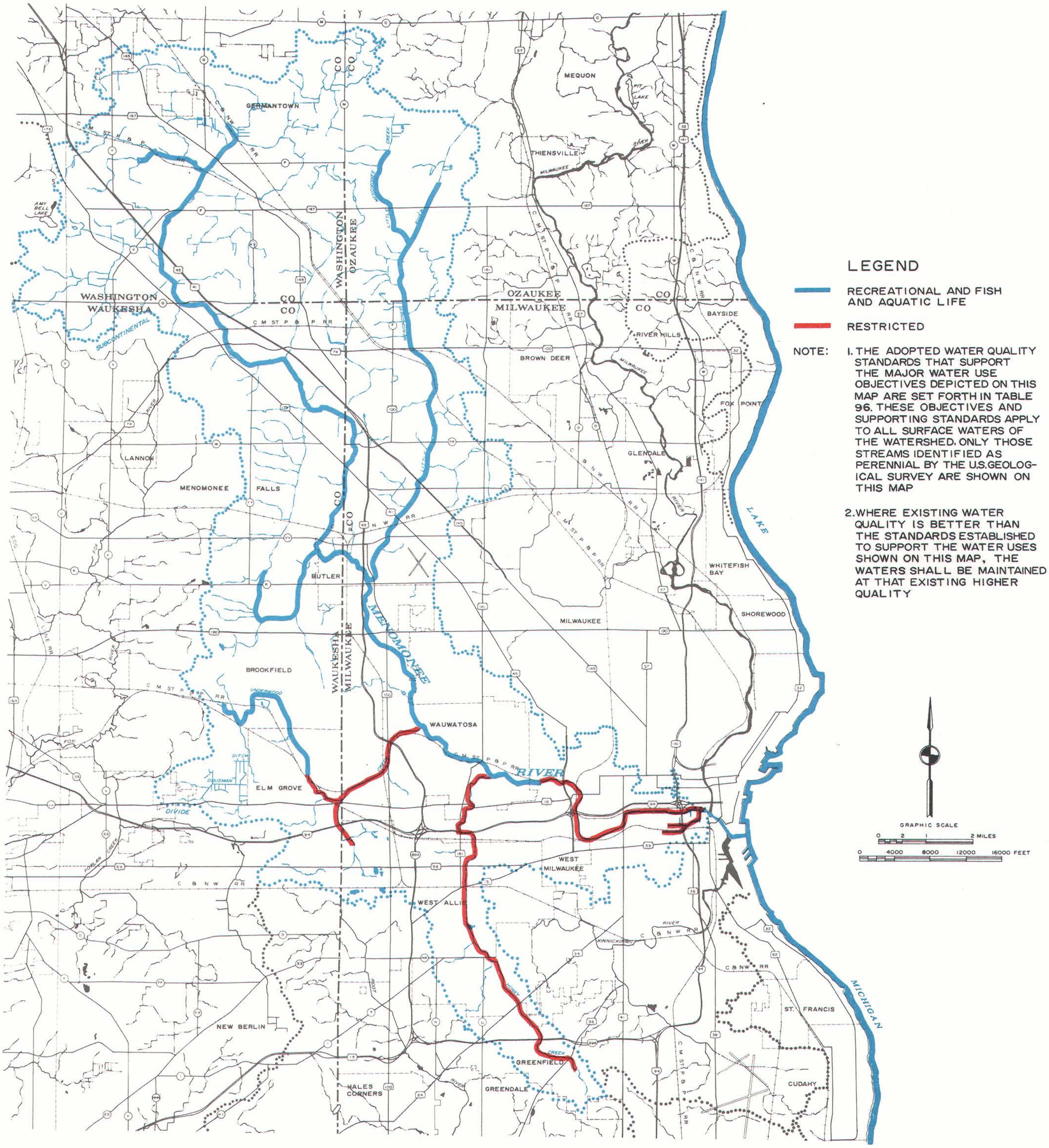
It should be noted that the planning standards herein recommended for adoption fall into two groups: comparative and absolute. The comparative standards, by their very nature, can be applied only through a comparison of alternative plan proposals. Absolute standards can be applied individually to each alternative plan proposal, since they are expressed in terms of maximum, minimum, or desirable values. The standards set forth herein should serve not only as aids in the development, test, and evaluation of watershed land use and water control facility plans but also in the development, test, and evaluation of local land use and community facility plans and in the development of plan implementation policies and programs as well.

Overriding Considerations

In the application of the watershed development objectives, principles, and standards in the preparation and evaluation of the watershed plan elements, several overriding considerations must be recognized. First, it must be recognized that any proposed water control and water quality management facilities must constitute integral parts of a total system. It is not possible from an application of the standards alone, however, to assure such a system integration, since the standards cannot be used to determine the effect of individual facilities and controls on each other or on the system as a whole. This requires the application of planning and engineering techniques developed for this purpose, such as hydrologic, hydraulic, and water quality simulation, to quantitatively test the potential performance of the proposed facilities as part of a total system, thereby permitting adjustment of the spatial distribution and capacities of the facilities and system to the existing and future runoff and waste loadings as derived from the land use plan. Second, it must be recognized that it is unlikely that any one plan proposal will meet all the standards completely; and the extent to which each standard is met, exceeded, or violated must serve as a measure of the ability of each alternative plan proposal to achieve the specific objectives which the given standard complements. Third, it must be recognized that certain objectives and standards may be in conflict and require resolution through compromise, such compromise being an essential part of any design effort.

Map 1

RECOMMENDED WATER USE OBJECTIVES FOR THE MENOMONEE RIVER WATERSHED



Water use objectives and supporting water quality standards constitute a significant input to the preparation of the comprehensive plan for the Menomonee River watershed. The existing state-adopted water use objectives for the surface waters of the Menomonee River watershed are identified on Map 82, Volume 1 of this report. The recommended water use objectives for the Menomonee River watershed are shown on the above map. The two maps differ in only one respect: that reach of the main stem of the Menomonee River from its confluence with Honey Creek in the City of Wauwatosa downstream to Hawley Road in the City of Milwaukee, which has been placed in the "restricted" category under the current state-adopted objectives, is recommended for upgrading to the "recreational and fish and aquatic life" category under the recommended Menomonee River watershed plan.

Source: SEWRPC.

Table 2

LAND USE DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE MENOMONEE RIVER WATERSHED

OBJECTIVE NO. 1

A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population.

PRINCIPLE

The planned supply of land set aside for any given use should approximate the known and anticipated demand for that use.

STANDARDS

1. For each additional 1,000 persons to be accommodated within the Region at each residential density, the following minimum amounts of land should be set aside:

Residential Density Category	Net Area[a] (Acres/1,000 Persons)	Gross Area[b] (Acres/1,000 Persons)
High Density Urban[c]	24	36
Medium Density Urban[c]	65	92
Low Density Urban[c]	238	298
Suburban[d]	572	698
Rural[d]	1,429	1,681

In addition, for each additional 1,000 persons to be accommodated within the Region the following minimum amounts of land should be set aside:

Land Use Category	Net Area[a] (Acres/1,000 Persons)	Gross Area[e] (Acres/1,000 Persons)
Governmental and Institutional	9	12
Public Park and Recreation		
Major.	4	5
Other.	9	10

2. For the daily use of short-term visitors to the watershed, the following amounts of land should be acquired and developed for each anticipated 100 participants[f] in each of the five major outdoor recreational activities which require intensive land development within the watershed:

Major Activity	Total Acres	Principal Development Acres	Backup Land or Secondary Development Acres
Swimming[g]	0.45	0.09	0.36
Picnicking[h]	12.50	1.25	11.25
Golfing[i]	32.79	32.79	--
Camping[j]	133.33	6.67	126.66
Skiing[k]	3.70	3.33	0.37

3. For each additional 100 commercial and industrial employees to be accommodated within the Region, the following minimum amounts of land should be set aside:

Land Use Category	Net Area[a] (Acres/100 Employees)	Gross Area[l] (Acres/100 Employees)
Commercial		
Major.	1	3
Other.	2	6
Industrial	2	9

Table 2 (continued)

OBJECTIVE NO. 2

A spatial distribution of the various land uses which will result in the protection, wise use, and development of the natural resources of the Region.

PRINCIPLE

The proper allocation of uses to land can assist in maintaining an ecological balance between the activities of man and the natural environment which supports him.

A. Soils

Principle

The proper relation of urban and rural land use development to soils type and distribution can serve to avoid many environmental problems, aid in the establishment of better regional settlement patterns, and promote the wise use of an irreplaceable resource.

STANDARDS

1. Sewered urban development, particularly for residential use, should not be located in areas covered by soils identified in the regional detailed operational soil survey as having severe or very severe limitations for such development.

2. Unsewered suburban residential development should not be located in areas covered by soils identified in the regional detailed operational soil survey as having severe or very severe limitations for such development.

3. Rural development, including agricultural and rural residential development, should not be located in areas covered by soils identified in the regional detailed operational soil survey as having severe or very severe limitations for such uses.

B. Wetlands

Principle

Wetlands support a wide variety of desirable and sometimes unique plant and animal life; assist in the stabilization of lake levels and streamflows; trap and store plant nutrients in runoff, thus reducing the rate of enrichment of surface waters and obnoxious weed and algae growth; contribute to the atmospheric oxygen supply; contribute to the atmospheric water supply; reduce storm water runoff by providing area for floodwater impoundment and storage; trap soil particles suspended in runoff and thus reduce stream sedimentation; and provide the population with opportunities for certain scientific, educational, and recreational pursuits.

STANDARD

All wetland areas[m] adjacent to streams or lakes, all wetlands within areas having special wildlife and other natural values, and all wetlands having an area in excess of 50 acres should not be allocated to any urban development except limited recreation and should not be drained or filled. Adjacent surrounding areas should be kept in open-space use, such as agriculture or limited recreation.

C. Woodlands[n]

Principle

Woodlands assist in maintaining unique natural relationships between plants and animals; reduce storm water runoff; contribute to the atmospheric oxygen supply; contribute to the atmospheric water supply through transpiration; aid in reducing soil erosion and stream sedimentation; provide the resource base for the forest product industries; provide the population with opportunities for certain scientific, educational, and recreational pursuits; and provide a desirable aesthetic setting for certain types of land use development.

STANDARDS

1. A minimum of 10 percent of the land area of each watershed[o] within the Region should be devoted to woodlands.

2. For demonstration and educational purposes, the woodland cover within each county should include a minimum of 40 acres devoted to each major forest type: oak-hickory, northern hardwood, pine, and lowland forest. In addition, remaining examples of the native forest vegetation types representative of the pre-settlement vegetation should be maintained in a natural condition and be made available for research and educational use.

3. A minimum regional aggregate of five acres of woodland per 1,000 population should be maintained for recreational pursuits.

D. Wildlife[p]

Table 2 (continued)

Principle

Wildlife, when provided with a suitable habitat, will provide the population with opportunities for certain scientific, educational, and recreational pursuits; comprises an integral component of the life systems which are vital to beneficial natural processes, including the control of harmful insects and other noxious pests and the promotion of plant pollination; provides a food source; provides an economic resource for the recreation industries; and is an indicator of environmental health.

STANDARD

The most suitable habitat for wildlife—that is, the area wherein fish and game can best be fed, sheltered, and reproduced—is a natural habitat. Since the natural habitat for fish and game can best be obtained by preserving or maintaining other resources in a wholesome state, such as soil, air, water, wetlands, and woodlands, the standards for each of these other resources, if met, would ensure the preservation of a suitable wildlife habitat and population.

OBJECTIVE NO. 3

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 economical provision of utility and municipal services.

PRINCIPLE

The transportation and public utility facilities and the land use pattern which these facilities serve and support are mutually interdependent in that the land use pattern determines the demand for, and loadings upon, transportation and utility facilities; and these facilities, in turn, are essential to, and form a basic framework for, land use development.

STANDARDS

1. The transportation system should be located and designed to minimize the penetration of existing and proposed residential neighborhood units by through traffic.

2. The transportation system should be located and designed to provide access not only to all land presently devoted to urban development but to land proposed to be used for such urban development.

3. Transportation terminal facilities, such as off-street parking, should be located in close proximity to the principal land uses to which they are accessory.

4. All land developed or proposed to be developed for urban medium- and high-density residential use should be located in areas serviceable by existing or proposed primary, secondary, and tertiary mass transit facilities.

5. All land developed or proposed to be developed for urban medium-, high-, and low-density residential use should be located in areas serviceable by an existing or proposed public sanitary sewerage system and preferably within the gravity drainage area tributary to such systems.

6. All land developed or proposed to be developed for urban medium-, high-, and low-density residential use should be located in areas serviceable by an existing or proposed public water supply system.

7. Urban development should be located so as to maximize the use of existing transportation and utility systems.

OBJECTIVE NO. 4

The preservation and provision of open space[q] 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 recreational program providing a full range of facilities for all age groups.

PRINCIPLE

Open space is the fundamental element required for the preservation, wise use, and development of such natural resources as soil, water, woodlands, wetlands, native vegetation, and wildlife; it provides the opportunity to add to the physical, intellectual, and spiritual growth of the population; it enhances the economic and aesthetic value of certain types of development; and it is essential to outdoor recreational pursuits.

Table 2 (continued)

STANDARDS[r]

1. Local park and recreation open spaces should be provided within a maximum service radius of one-half mile of every dwelling unit in an urban area, and each site should be of sufficient size to accommodate the maximum tributary service area population at a use intensity of 675 persons per acre.

2. Regional park and recreation open spaces should be provided within an approximately one hour travel time of every dwelling unit of the Region, and should have a minimum site area of 250 acres.

3. Areas having unique scientific, cultural, scenic, or educational value should not be allocated to any urban or agricultural land uses; and adjacent surrounding areas should be retained in open space use, such as agriculture or limited recreation.

OBJECTIVE NO. 5

The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture, provide a reserve 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.

PRINCIPLE

Agricultural areas, in addition to providing food and fiber, can provide significant wildlife habitat; ecological balance between plants and animals; provide locations proximal to urban centers for the production of certain food commodities which may require nearby population concentrations for an efficient production-distribution relationship; and provide open spaces which give form and structure to urban development.

STANDARDS

1. All prime agricultural areas[s] should be preserved.

2. All agricultural lands surrounding adjacent high-value scientific, educational, or recreational resources and covered by soils rated in the regional detailed operational soil survey as very good, good, or fair for agricultural use should be preserved.

In addition to the above, attempts should be made to preserve agricultural areas which are covered by soils rated in the regional detailed operational soil survey as fair if these soils: a) generally occur in concentrations greater than five square miles and surround or lie adjacent to areas which qualify under either of the above standards, or b) occur in areas which may be designated as desirable open spaces for shaping urban development.

OBJECTIVE NO. 6

The attainment of good soil and water conservation practices in order to reduce storm water runoff, soil erosion, and stream and lake sedimentation, pollution, and eutrophication.

PRINCIPLE

Good soil and water conservation practices, including mulch tillage, terracing, grassed waterways, contour strip cropping, and suitable crop rotation in rural areas; seeding; sodding; erosion control structures for drainageways; erosion control structures at storm sewer outlets; and proper land development and construction methods and practices, particularly in urban areas, including maximum possible delay in stripping of vegetation, construction of sediment basins, and mulching and revegetating as soon as possible, can assist in reducing storm water runoff, soil erosion, and stream and lake siltation, pollution, and eutrophication.

STANDARDS

1. The area of the watershed in cultivated agricultural use, which has general land slopes greater than 2 percent, should be under district cooperative soil and water conservation agreements and planned conservation treatment.

2. Drainageways should be controlled to eliminate channel erosion both through stabilization of bank and bed materials and by reduction of the channel gradient.

3. All urban and structural plans and developments, where soil and vegetative cover is removed, should include soil and water conservation practices to control erosion on critical areas.

4. Runoff through and from areas with exposed soil should be trapped and stored or retarded to less than critical erosive velocities.

Table 2 (continued)

[a] Net land use area is defined as the actual site area devoted to a given use, and consists of the ground floor site area occupied by any buildings plus the required yards and open spaces.

[b] Gross residential land use area is defined as the net area devoted to this use plus the area devoted to all supporting land uses, including streets, neighborhood parks and playgrounds, elementary schools, and neighborhood institutional and commercial uses, but not including freeways and expressways and other community and areawide uses.

[c] Areas served, proposed to be served, or required to be served by public sanitary sewerage and water supply facilities; requires neighborhood facilities.

[d] Areas not served, not proposed to be served, nor required to be served by public sanitary sewerage and water supply facilities; does not require neighborhood facilities.

[e] Gross governmental and institutional area is defined as the net area devoted to governmental and institutional use plus the area devoted to supporting land uses, including streets and onsite parking. Gross public park and recreation area is defined as the net area devoted to active or intensive recreation use plus the adjacent "backup" lands and lands devoted to other supporting land uses such as roads and parking areas.

[f] A participant is defined as a person 12 years of age or older who actively participates in a particular recreational activity on a given day.

[g] Swimming—One acre of developed beach area can accommodate approximately 370 people at any one time. With a daily turnover rate of 3.0, the maximum capacity of one acre of developed beach is 1,110 people per acre per day. In addition, for every one acre of developed beach area, four (4) acres of backup lands are required to provide necessary parking area (approximately one and one-half acres), concession services, dressing room area (approximately one acre), and other activity area, such as picnic area (approximately one and one-half acres).

[h] Picnicking—One acre of developed picnic area with a maximum of 16 tables can accommodate approximately 50 people at any one time. With a daily turnover rate of 1.6, the maximum capacity of one acre of developed picnic area is 80 people per acre per day. In addition, for every one acre of developed picnic area, nine (9) acres of backup land are required to provide necessary parking area and additional secondary facilities.

[i] Golfing—A minimum of 10 acres of land per hole is required to develop a regulation 9- or 18-hole golf course, including area for clubhouse and parking, and will accommodate approximately one golfer per acre at any one time. With a daily turnover rate of 3.0, the maximum capacity of each golf course is 3.0 golfers per acre per day, or 30 golfers per hole per day.

[j] Camping—One acre of developed camp area with a maximum of five camp units can accommodate approximately 15 people per day. There is no daily turnover rate for camping. In addition, for every one acre of developed camp area, nineteen (19) acres of backup land are required to provide necessary supporting activities or facilities, such as central convenience facilities, hiking and nature trails, picnic areas, boat and canoe launching sites, and horseback trails.

[k] Skiing—One acre of developed ski slope can accommodate approximately 10 people at any one time. With a daily turnover rate of 3.0, the maximum capacity of one acre of developed ski slope is 30 people per acre per day. In addition, for every 10 acres of developed ski slope, one acre of backup land is required to provide parking and concession facilities. The recommended minimum site area is 100 acres.

[l] Gross commercial and industrial area is defined as the net area devoted to these uses plus the area devoted to supporting land uses, including streets and off-street parking.

[m] Wetlands are defined as those lands which are wholly or partially covered with hydrophytic plants and wet and spongy organic soils, and which are generally covered with shallow standing water, intermittently inundated, or have a high water table.

[n] Woodlands are defined as lands at least 20 acres in area which are covered by a dense, concentrated stand of trees and associated undergrowth.

[o] A watershed, as used herein, is defined as a portion of the surface of the earth occupied by a surface dainage system discharging all surface water runoff to a common outlet and which is 25 square miles or larger in areal extent.

[p] Includes all fish and game.

[q] Open space is defined as land or water areas which are generally undeveloped for residential, commercial, or industrial uses and are or can be considered relatively permanent in character. It includes areas devoted to park and recreation uses and to large land-consuming institutional uses, as well as areas devoted to agricultural use and to resource conservation, whether publicly or privately owned.

[r] It was deemed impractical to establish spatial distribution standards for open space, per se; therefore, only the park and recreation component of the open space land use category is listed in the standards, according to its local or regional orientation. These local park and recreation spaces may include playlots, playgrounds, playfields, and neighborhood parks. Regional park and recreation spaces include large county or state parks. Other open spaces which are not included in this spatial distribution standard are: forest preserves and arboreta; major river valleys; lakes; zoological and botanical gardens; stadia; woodland, wetland, and wildlife areas; scientific areas; and agricultural lands whose location must be related to, and determined by, the natural resource base.

[s] Prime agricultural areas are defined as those areas which a) contain soils rated in the regional detailed operational soil survey as very good or good for agriculture and b) occur in concentrated areas over five square miles in extent which have been designated as exceptionally good for agricultural production by agricultural specialists.

Source: SEWRPC.

ENGINEERING DESIGN CRITERIA AND ANALYTIC PROCEDURES

As noted earlier in this chapter, certain engineering design criteria and analytic procedures were utilized in the preparation of the watershed plan. More specifically, these criteria and procedures were used in the design of alternative plan elements, in the test of the technical feasibility of those elements, and in the making of the necessary economic comparisons. While these engineering criteria and procedures are widely accepted and firmly based in current engineering practice, it is, nevertheless, believed useful to document these here.

Rainfall Intensity-Duration-Frequency Relationship

If local storm water drainage as well as river flood control measures are to be compatible and function in a coordinated manner, plans for both must be based on consis-

Table 3

SANITARY SEWERAGE SYSTEM DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE MENOMONEE RIVER WATERSHED

OBJECTIVE NO. 1

The development 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 sanitary waste disposal demand generated by the existing proposed land uses.

PRINCIPLE

Sanitary sewerage systems are essential to the development and maintenance of a safe, healthy, and attractive urban environment, and the extension of existing sanitary sewerage 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 and suburban[d] 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. 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.

4. 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, may be provided with sanitary sewer service. Engineering analyses relating to the sizing of sanitary sewerage facilities should assume the permanent preservation of all undeveloped primary environmental corridor lands in natural open-space uses.

5. 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 watershed plans, may be provided with sanitary sewer service. Engineering analyses relating to the sizing of sewerage facilities should not assume ultimate development of floodlands for urban use.

6. Significant concentrations[f] of land 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 facilities should not assume ultimate urban development of such lands for urban use.

7. The timing of the extension of sanitary sewerage facilities should, insofar as possible, seek to promote urban development in a series of complete neighborhood planning 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.

8. The sizing of sewerage facility components should be based upon an assumption that future land use development will occur in general accordance with the land use pattern recommended in the regional land use plan.

9. 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.

OBJECTIVE NO. 2

The development of sanitary sewerage systems that are properly related to, and that will enhance the overall quality of, the natural and manmade environments.

Table 3 (continued)

PRINCIPLE

The improper location, design, construction, operation, and maintenance of sewerage system 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 0.5 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 sewage treatment plants should be properly related to the existing and proposed future urban development pattern as reflected in the regional land use plan and 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 enougn 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.

OBJECTIVE NO. 3

The development of sanitary sewerage systems that are both economical and efficient, meeting all other objectives at the lowest cost possible.

PRINCIPLE

The total resources of the Region are limited, and any undue investment in sanitary sewerage systems must occur at the expense of other public and private investment. Total sewerage system 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 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 economies in manpower utilization and minimize duplication of administrative, laboratory, storage, sludge disposal, and other necessary appurtenant facilities and equipment.

3. Maximum feasible use should be made of all existing and committed sanitary sewerage facilities. Such facilities should be supplemented with additional facilities only as necessary to serve the anticipated sanitary waste demand generated by substantial implementation of the regional land use plan, while meeting pertinent water quality use objectives and standards.

4. 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 cost, or if by their superior performance lead to the achievement of water quality objectives at lesser costs.

Table 3 (continued)

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

6. 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.

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

8. Sanitary sewerage systems and storm water drainage systems should be designed and developed concurrently in order 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 pollution abatement and drainage benefits of the integrated design; and to minimize disruption of the natural resource base and existing urban development.

[a] *Medium-density residential development is defined as that development having an average number of dwelling units per gross acre of 2.6 and a net lot area per dwelling unit ranging from 6,231 to 18,980 square feet.*

[b] *High-density residential development is defined as that development having an average number of dwelling units per gross acre of 5.8 and a net lot area per dwelling unit ranging from 2,439 to 6,230 square feet.*

[c] *Low-density residential development is defined as that development having an average number of dwelling units per gross acre of 0.8 and a net lot area per dwelling unit ranging from 18,981 to 62,680 square feet.*

[d] *Suburban residential development is defined as that development having an average number of dwelling units per gross acre of 0.30 and a net lot area per dwelling unit ranging from 62,681 to 217,800 square feet.*

[e] *Floodlands are defined as those lands, including the 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 over 160 acres in extent.*

Source: SEWRPC.

tent engineering design criteria. A fundamental criterion for both local and watershed drainage planning is the rainfall intensity-duration-frequency relationship representative of the watershed area.

The Commission has developed rainfall intensity-duration-frequency relationships, based on a 64-year precipitation record at the Milwaukee National Weather Service station. These relationships are shown graphically and in equation form in Appendix C. The curves in Figure C-1 and the equations in Table C-1 are directly applicable to urban storm water drainage system design using the rational formula,[4] with the equations being intended primarily for incorporation into digital computer programs used in storm water drainage system analysis and design.

The curves in Figure C-2, which relate total rainfall to duration and frequency, are more convenient for use in basin-wide hydrologic analysis. The variation of rainfall depth with area of consideration and the seasonal variation of rainfall probability are described in Figures C-3 and C-4, respectively. All these rainfall relationships are directly applicable to the Menomonee River watershed as well as the Southeastern Wisconsin Planning Region.

Storm Sewer Design Criteria

Rainfall intensity-duration-frequency relationships and soil survey data make possible a detailed consideration of rainfall-runoff relationships in the design of storm sewers

[4] *For a detailed description of the rational method with emphasis on the use of soils, mapping, land use, and hydrologic data available for the seven-county Planning Region, refer to "Determination of Runoff for Urban Storm Water Drainage System Design" by K. W. Bauer, SEWRPC Technical Record, Volume 2, No. 4, April-May 1965. The procedures used to obtain equations for intensity-duration-frequency relationships are described in "Development of Equations for Intensity-Duration-Frequency Relationships" by S. G. Walesh, SEWRPC Technical Record, Volume 3, No. 5, March 1973.*

Table 4

WATER CONTROL FACILITY DEVELOPMENT OBJECTIVES, PRINCIPLES, AND STANDARDS FOR THE MENOMONEE RIVER WATERSHED

OBJECTIVE NO. 1

An integrated system of drainage and flood control facilities and floodland management programs which will effectively reduce flood damage under the existing land use pattern of the watershed and promote the implementation of the watershed land use plan, meeting the anticipated runoff loadings generated by the existing and proposed land uses.

PRINCIPLE

Reliable local municipal storm water drainage facilities cannot be properly planned, designed, or constructed except as integral parts of an areawide system of floodwater conveyance and storage facilities centered on major drainageways and perennial waterways designed so that the hydraulic capacity of each waterway opening and channel reach abets the common aim of providing for the storage, as well as the movement, of floodwaters. Not only does the land use pattern of the tributary drainage area affect the required hydraulic capacity, but the effectiveness of the floodwater conveyance and storage facilities affects the uses to which land within the tributary watershed, and particularly within the riverine areas of the watershed, may properly be put.

STANDARDS

1. All new and replacement bridges and culverts over perennial waterways shall be designed so as to accommodate, according to the categories listed below, the designated flood events without overtopping of the related roadway or railroad track and resultant disruption of traffic by floodwaters.

   a. Minor and collector streets used or intended to be used primarily for access to abutting properties: a 10-year recurrence interval flood discharge.

   b. Arterial streets and highways, other than freeways and expressways, used or intended to be used primarily to carry heavy volumes of fast, through traffic: a 50-year recurrence interval flood discharge.

   c. Freeways and expressways: a 100-year recurrence interval flood discharge.

   d. Railroads: a 100-year recurrence interval flood discharge.

2. All new and replacement bridges and culverts over perennial waterways, including pedestrian and other minor bridges, in addition to meeting the applicable above-specified requirements, shall be designed so as to accommodate the 100-year recurrence interval flood event without raising the peak stage, either upstream or downstream, more than 0.5 foot above the peak stage for the 100-year recurrence interval flood, as established in the adopted comprehensive watershed plan. Larger permissible flood stage increases may be acceptable for reaches having topographic or land use conditions which could accommodate the increased stage without creating additional flood damage potential upstream or downstream of the proposed structure.

3. The waterway opening of all new and replacement bridges shall be designed so as to readily facilitate the passage of ice floes and other floating debris, and thereby avoid blockages often associated with bridge failure and with unpredictable backwater effects and flood damages. In this respect it should be recognized that clear spans and rectangular openings are more efficient than interrupted spans and curvilinear openings in allowing the passage of ice floes and other floating debris.

4. Certain new or replacement bridges and culverts over perennial waterways, including pedestrian and other minor bridges, so located with respect to the stream system that the accumulation of floating ice or other debris may cause significant backwater effects with attendant danger to life, public health or safety, or attendant serious damage to homes, industrial and commercial buildings, and important public utilities, shall be designed so as to pass the 100-year recurrence interval flood with at least 2.0 feet of freeboard between the peak stage and the low concrete or steel in the bridge span.

5. Standards 1, 3, and 4 shall also be used as the criteria for assessment of the adequacy of the hydraulic capacity and structural safety of existing bridges or culverts over perennial waterways and thereby serve, within the context of the adopted comprehensive watershed plan, as the basis for crossing modification or replacement recommendations designed to alleviate flooding and other problems.

6. Channel modifications, dikes, and floodwalls should be restricted to the minimum number and extent absolutely necessary for the protection of existing and proposed land use development, which development is consistent with the land use element of the comprehensive watershed plan; the upstream and downstream effect of such structural works on flood discharges and stages shall be determined; and any such structural

works which may significantly increase upstream or downstream peak flood discharges should be used only in conjunction with complementary facilities for the storage and movement of the incremental floodwaters through the watershed stream system. Channel modifications, dikes, or floodwalls shall not increase the height of the 100-year recurrence interval flood by more than one-half foot in any unprotected upstream or downstream stream reaches. Increases in flood stages in excess of one-half foot resulting from any channel, dike, or floodwall construction shall be contained within the upstream or downstream extent of the channel, dike, or floodwall, except where topographic or land use conditions could accommodate the increased stage without creating additional flood damage potential.

7. The height of dikes and floodwalls shall be based on the high water surface profiles for the 100-year recurrence interval flood prepared under the comprehensive watershed study, and shall be capable of passing the 100-year recurrence interval flood with a freeboard of at least two feet.

8. The construction of channel modifications, dikes, or floodwalls shall be deemed to change the limits and extent of the associated floodways and floodplains. However, no such change in the extent of the associated floodways and floodplains shall become effective for the purposes of land use regulation until such time as the channel modifications, dikes, or floodwalls are actually constructed and operative. Any development in a former floodway or floodplain located to the landward side of any dike or floodwall shall be provided with adequate drainage so as to avoid ponding and associated damages.

9. Reduced regulatory flood protection elevations and accompanying reduced floodway or floodplain areas resulting from any proposed dams or diversion channels shall not become effective for the purposes of land use regulation until the reservoirs or channels are actually constructed and operative.

10. All water control facilities other than bridges and culverts, such as dams and diversion channels, so located on the stream system that failure would damage only agricultural lands and isolated farm buildings, shall be designed to accommodate at least the hydraulic loadings resulting from a 100-year recurrence interval flood. Water control facilities so located on the stream system that failure could jeopardize public health and safety, cause loss of life, or seriously damage homes, industrial and commercial buildings, and important public utilities or result in closure of principal transportation routes shall be designed to accommodate a flood that approximates the standard project flood or the more severe probable maximum flood, depending on the ultimate probable consequences of failure.[a]

PRINCIPLE

Floodlands that are unoccupied by, and not committed to, urban development should be retained in an essentially natural open space condition supplemented with the development of selected areas for public recreational uses. Maintaining floodlands in open uses will serve to protect one riverine community from the adverse effects of the actions of others by discouraging floodland development which would significantly aggravate existing flood problems or create new flood problems upstream or downstream; will preserve natural floodwater conveyance and storage capacities; will avoid increased peak flood discharges and stages; will contribute to the preservation of wetland, woodland, and wildlife habitat as part of a continuous linear system of open space, and will immeasurably enhance the quality of life for both the urban and rural population by preserving and protecting the recreational, aesthetic, ecological, and cultural values of riverine areas.

STANDARDS

1. All public land acquisitions, easements, floodland use regulations, and other measures intended to eliminate the need for water control facilities shall, in all areas not already in intensive urban use or committed to such use, encompass at least all of the riverine areas lying within the 100-year recurrence interval flood inundation line.

2. Where hydraulic floodways are to be delineated, they shall to the maximum extent feasible accommodate existing, committed, and planned floodplain land uses.

3. In the determination of a hydraulic floodway, the hydraulic effect of the potential floodplain encroachment represented by the floodway 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 to not raise the peak stage of the 100-year recurrence interval flood by more than 0.5 foot. Larger stage increases may be acceptable for reaches having topographic or land use conditions which could accommodate such stage increases, whereas in some instances, allowable flood stage increases may be less than 0.5 foot where such increased stages may be expected to significantly aggravate flood problems and increase flood damages, and where adjoining communities are affected.

OBJECTIVE NO. 2

An integrated system of land management and water quality control facilities and pollution abatement devices adequate to assure a quality of surface water necessary to meet the water uses shown on Map 1.

Table 4 (continued)

PRINCIPLE

Surface water is one of the most valuable resources of southeastern Wisconsin; and, even under the effects of increasing population and economic activity levels, the potential of natural stream waters to serve a reasonable variety of beneficial uses, in addition to the single-purpose function of waste transport and assimilation, should be protected and preserved.

STANDARDS

1. All waters shall meet those water quality standards set forth in Table 96 of this report commensurate with the adopted water use objectives.

2. Water quality standards commensurate with adopted water use objectives are applicable at all times except during periods when streamflows are less than the average minimum seven-day low flow expected to occur on the average of once every 10 years.

OBJECTIVE NO. 3

The attainment of sound groundwater resource development and protective practices to minimize the possibility for pollution and depletion of the groundwater resources.

PRINCIPLE

Sound practices in the location, installation, and operation of water supply wells and waste treatment and disposal facilities can reasonably assure a continuing supply of good quality groundwater at reasonable cost.

STANDARDS

1. Groundwater withdrawals should be made so as to prevent undue interference with adjacent withdrawal points, and the capacities and withdrawal rates should be related to potential yield and total demand on the aquifers penetrated.

2. Wells should be constructed so as not to permit contamination of the aquifer through the well during construction or during subsequent operation.

3. Waste conveyance, treatment, and disposal facilities, located above or below ground surface, both public and private, should be designed, constructed, and operated in a manner to prevent migration or infiltration of contaminants into sources of usable groundwater. These facilities include pipes, tunnels, septic tanks, leaching areas, sanitary landfills, and injection wells.

[a] *These flood events, which have been formulated and used by the U. S. Army Corps of Engineers, are defined and discussed in Chapter VII, SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, November 1968.*

Source: SEWRPC.

for urban areas in the Southeastern Wisconsin Region and in the watershed. Recommended values for the coefficient of runoff, C, which are based on land use, land slope, and soil type, are presented in Appendix C, Figure C-5 and Table C-2.[5] Soils which occur in the watershed and the Southeastern Wisconsin Region are categorized in hydrologic groups according to their infiltration capabilities in Appendix C of SEWRPC Planning Guide No. 6, Soils Development Guide.

Flood Discharge-Frequency Analyses

Each point on a watershed stream system has, for a given land use condition, a unique discharge-frequency relationship, which is normally presented graphically and relates possible annual peak discharges in cubic feet per second to the average frequency or recurrence interval in years at which the indicated discharge will be reached or exceeded. Discharge-frequency analyses of annual flood peaks were conducted under the Menomonee River watershed study according to the log-Pearson Type III method of analyses as recommended by the United States Water Resources Council[6] and as specified by the Wisconsin Department of Natural Resources.[7] In addition to

[5] *Ibid.*

[6] *"A Uniform Technique for Determining Flood-Flow Frequencies," Bulletin No. 15, United States Water Resources Council, Washington, D. C., 1967.*

[7] *Wisconsin Administrative Code, "Wisconsin's Floodplain Management Program," Chapter NR 116, Register, May 1971, No. 185.*

applying this statistical technique to annual peak discharges as measured on the Menomonee River gage in Wauwatosa for the 12-year period October 1961 through September 1973, the log-Pearson Type III method of analysis was also applied to simulated annual peak discharges at points of interest scattered throughout the watershed stream system so as to produce, in effect, watershedwide simulated discharge-frequency relationships. These discharge-frequency relationships were used to determine the magnitude of the 100-year recurrence interval regulatory flood, and were also used for computation of monetary flood damages and for calculation of economic benefits associated with alternative floodland management measures.

Design Flood

The design flood adopted for the Menomonee River watershed is that event having a 100-year recurrence interval peak discharge under year 2000 recommended watershed plan conditions. This discharge was determined for locations distributed throughout the watershed stream system and used to delineate the 100-year recurrence interval floodlands, which in turn served as the basis for development and testing of alternative plans and selection of the recommended plan. For example, the 100-year recurrence interval flood hazard line was used to define those structures included in the synthesis of annual flood damages, and that flood hazard line was also used to delineate minimum areas recommended for open space use in rural portions of the watershed.

The selection of the design flood should be dictated by careful consideration of factors such as available hydrologic data, watershed flood characteristics, and costs attributable to flooding relative to benefits accruing to various floodplain management alternatives, but in the final analysis, it is as much a matter of public policy as it is of engineering practice and economic analysis. Sound engineering practice, however, dictates that the flood used to delineate floodlands for land use regulation purposes have a specific recurrence interval so that economic analyses of the costs and benefits of alternative flood control plans can be made, and the advantages and disadvantages of various levels and combinations of police power regulation, public acquisition, and public construction for flood damage abatement and prevention can be analyzed on a comparable basis.

The Commission has selected the 100-year recurrence interval flood as the design flood for all of its watershed planning efforts for the following reasons:

1. A 100-year recurrence interval flood approximates, with respect to the amount of land inundated, the largest known floods that have actually occurred in the Region since its settlement by Europeans, although not all streams within the Region have experienced floods as large as the 100-year recurrence interval flood. For example, the largest flood of record for the Menomonee River watershed as recorded near the watershed outlet at Wauwatosa was estimated to have had a recurrence interval of approximately 100 years; the two largest floods of record for the Milwaukee River watershed as measured near the watershed outlet at Milwaukee were estimated to have had a recurrence interval of 77 years; the largest flood of record for the Fox River watershed, as observed near the watershed outlet at Wilmot near the Wisconsin-Illinois border, was estimated to have had a recurrence interval of 37 years; and the largest flood of record for the Root River watershed as determined in Racine at the watershed outlet was estimated to have had a recurrence interval of 100 years. For regulatory purposes, the use of a flood event that is similar in terms of peak flood stages and corresponding area of inundation to the most severe flood which has actually occurred within the Region provides a means by which engineers, planners, and community leaders can meaningfully relate the seriousness of the flood problem to the public, and thereby obtain understanding of the need for floodland management.

2. The 100-year recurrence interval flood is judged to be a reasonably conservative choice when viewed in the context of the full range of possible regulatory flood events which could be used. A primary function of the regulatory flood is to define, by means of a floodplain and associated floodway, those riverine areas in which urbanization should be prohibited or strictly controlled. The regulatory flood should be at least as severe as the 10-year recurrence interval flood, since it would not be in the best interest of either the public in general or potential riverine property owners in particular to allow or encourage urban development in areas that are subject to inundation as frequently or more frequently than an average of once every 10 years. This is particularly true where the flooding may endanger the health or safety of floodplain inhabitants and require that costly rescue, cleanup, and repair work be undertaken by local units of government.

   The inadequacy of the 10-year flood event as the regulatory flood thus requires selection of a more severe event, such as the recurrence interval floods of 25, 50, or 100 years. Hydrologic and hydraulic analyses completed as part of comprehensive Commission watershed studies indicate that the streams and rivers of southeastern Wisconsin generally exhibit relatively small incremental differences in stage and areas of inundation as floods increase in severity from the 10- to the 100-year event. Flood discharges in this range exceed channel capacity so that the river occupies and flows on its floodplain. Because of the large cross-sectional area of flow made available on the relatively broad floodplains characteristic of the streams of the planning region, a situation is produced in which large increments of additional discharge are accommodated with relatively small stage increases. Therefore, the stage of a 100-year recurrence interval flood will normally be only a few feet above the 10-year stages, although discharges of the former are usually almost twice that of the latter. The differences between the stages of a 25- or 50-year recurrence interval flood event and the 100-year recurrence interval flood event are generally even smaller. The floodplains, moreover, are normally bounded on the outer fringes by relatively steep slopes leading to higher topography, and as a consequence of this lateral confinement, the area subject to inundation increases relatively little as floods increase in severity from the 10- to 100-year events.

Use of the 100-year recurrence interval flood event thus provides a greatly reduced probability of occurrence, yet entails only a relatively small incremental increase in stage and, therefore, in the area subject to regulation. Thus, the 100-year event, as opposed to the 25- or 50-year event, is recommended as the basis for floodland regulation.

3. Use of the 100-year recurrence interval flood for floodplain management purposes was recommended for use by federal agencies in 1969[8] by the Water Resources Council, an organization composed of representatives of federal offices and agencies concerned with water resources problems. This Water Resource Council recommendation, in effect, formalizes a generally accepted practice followed by federal agencies, such as the U. S. Army Corps of Engineers and the U. S. Soil Conservation Service, of using the 100-year recurrence interval flood as the design flood for water resources planning purposes. The Commission's use of the 100-year recurrence interval flood as the design flood results in watershed plans that have floodland management recommendations which are in accord with federal water resources planning procedures. This is particularly important with respect to any plan recommendations that may require federal participation for implementation.

4. Subsequent to the Commission recommendation that the 100-year recurrence interval flood serve as the basis for floodland regulations in southeastern Wisconsin, the Wisconsin Legislature, in August 1966, enacted the State Water Resources Act. It authorizes and directs the Wisconsin Department of Natural Resources to carry out a statewide program leading to the adoption of reasonable and effective floodland regulations by all counties, cities, and villages. One of the requirements of the resulting state floodplain management program is that floodland regulations be based on the regional flood, which is defined by the Department as being the 100-year recurrence interval flood. Therefore, the use of the 100-year flood for land use regulatory purposes as originally recommended by the Commission is now mandatory within Wisconsin.

[8] *Water Resources Council, "Proposed Flood Hazard Evaluation Guidelines for Federal Executive Agencies," Washington, D. C., September 1969.*

Digital Computer Utilization

Extensive use was made of digital computers in the conduct of the Menomonee River as well as in other Commission watershed studies. Computer utilization minimized manual data handling, and facilitated the incorporation of more sophisticated analytical procedures into the planning process. The Commission staff as well as the staffs of consultants and participating agencies were thus able to direct more of their efforts toward, and to be more effective in, the study design, objective formulation, analysis and forecast, plan synthesis, and plan testing phases of the watershed planning program. More specifically, extensive use was made of the digital computer in the Menomonee River watershed planning program for the four reasons discussed below.

Rationale for Computer Use: First, use of the digital computer encourages, and in fact demands, a systematic disciplined approach to the planning process on behalf of participating engineers, planners, and technicians. Inasmuch as successful computer operation requires that all desired operations be completely and correctly programmed, it follows that each watershed study work element intended for computer utilization must be examined in its entirety and designed in detail prior to actually acquiring, collating, and preparing input data and writing computer instructions.

Second, a digital computer system can store large amounts of alpha-numerical information, and more importantly, facilitate the retrieval and processing of such information. When the computer is used, therefore, inventory data need be manually handled only once—during the coding stage—with all subsequent data processing operations being performed by the computer system.

Third, the digital computer can accurately perform large numbers of repetitive computations in a very small fraction of the time required for manual calculation. Because of the staff time requirements and associated monetary costs, it would, for example, have been absolutely impossible to manually perform the computations executed by the digital computer hydrologic-hydraulic-water quality models used in the watershed study. The principal value of the digital computer's speed, therefore, is that it facilitates the application of state-of-the-art analysis methods on a watershed-wide basis.

Fourth, computer usage results in the basic watershed study data and information being stored in a form that is readily manageable and usable during plan implementation. Computer files and computer program input data are, relative to other forms of data and information storage, readily amended or revised as new or more accurate data become available subsequent to completion of the watershed plan.

Types of Computer Use: Digital computers were used to perform two basic functions in the watershed planning effort—an engineering computation function and a system simulation function. There are overlaps between, and common aspects among, these two functions, but a two-part categorization is useful for the following description of the manner in which digital computer systems were employed in preparation of the watershed plan.

Engineering Computations: As summarized in Table 5, several computer programs were used to perform engineering computations under the watershed study. These computer programs, some of which were written by the Commission staff, were used to perform a variety of operations, including, for example, analysis of annual peak streamflow records to develop discharge-frequency relationships and computation of potential evaporation as a function of temperature, wind movement, solar radiation, and dewpoint.

System Simulation: The achievement of the necessary detailed understanding of the spatial and temporal fluctuations in the quantity and quality of watershed surface water resources, under both existing and hypo-

Table 5

DIGITAL COMPUTER UTILIZATION IN THE MENOMONEE RIVER WATERSHED STUDY

Type of Computer Use[b]	Name of Computer Program	Function of Computer Program	Source of Computer Program[a]		
			Program Written by:	Date of Original Development	Documentation
Engineering Computation	Log-Pearson Type III Flood Frequency Analysis	Fit a Log-Pearson Type III frequency relation to a set of annual peak discharges and determine various statistical parameters including the 1- through 100-year recurrence interval discharges	U. S. Geological Survey, Surface Water Branch	1972	U. S. Geological Survey, Surface Water Branch, "Log-Pearson Type III Frequency Analysis," Computer Program E675, February 1972
	U. S. Geological Survey Regional Method of Flood Flow Determination	Calculate 2-, 5-, 10-, 25-, 50-, and 100-year recurrence interval discharges for rural areas as a function of basin parameters such as slope and size of tributary area	SEWRPC	November 1974	Conger, D. H., "Estimating Magnitude and Frequency of Floods in Wisconsin," U. S. Geological Survey, Madison, 1971; and SEWRPC files
	Solar Radiation Calculation	Calculate solar radiation at the ground surface as a function of percent of possible sunshine, latitude, and time of year	Hydrocomp, Inc.	Date of original development not available. Revised by SEWRPC in November 1974	Hamon, R. W., Weiss, L. L., and Wilson, W. T., "Insolation as an Empirical Function of Daily Sunshine Duration," Monthly Weather Review, Vol. 82, No. 6, June 1954; and SEWRPC files
	Wind Speed Calculation	Calculate average daily wind speed as a function of maximum daily wind speed and calculate wind speed near the ground as a function of wind speed at a higher elevation	SEWRPC	January 1975	Linsley, R. K., Kohler, M. A., and Paulhus, J. L. H., Hydrology for Engineers, Second Edition, 1975, pp. 41-46; and SEWRPC files
	Dewpoint Temperature Calculation	Calculate dewpoint temperature at the ground surface as a function of wet and dry bulb temperature and atmospheric pressure	SEWRPC	January 1975	List, R. J., Smithsonian Meteorological Tables, Sixth Revised Edition, Smithsonian Miscellaneous Collection, Vol. 114, Smithsonian Institution Press, Washington, D. C., 1949; and SEWRPC files
	Potential Evaporation Calculation	Estimate potential evaporation as a function of daily temperature, wind movement, solar radiation, and dewpoint	SEWRPC	February 1975	Lamoreux, W. W., "Modern Evaporation Formulae Adapted to Computer Use," Monthly Weather Review, January 1962; and SEWRPC files

thetical watershed development conditions, requires application of some planning technique which can supplement the available water resources inventory data. River performance simulation, accomplished with a combination of interrelated digital computer programs, has proven to be such a planning technique, having been used effectively in the Commission's comprehensive studies of the Root, Fox, and Milwaukee River watersheds. Based on its effectiveness in those watersheds, river performance simulation was also used by SEWRPC in the Menomonee River watershed study.

Before defining and discussing simulation, it is useful to point out that in river performance simulation, the watershed is considered to be a system; that is, a set of interdependent physical units and processes organized or arranged so as to interact in a predictable, regular manner, the understanding or manipulation of which can be used to advance some objective or function. With the preceding definition and example of a system in mind, simulation may in turn be defined as reproduction of the important behavioral aspects of a system.

Digital computer simulation differs from the other type of watershed study computer applications—the engineering computation function—in that simulation represents watershed hydrologic, hydraulic, and water quality and related phenomena as they actually occur in the "real world" watershed system, except, of course, at a greatly accelerated rate. In order to simulate a watershed system, it is necessary to construct a mathematical model or algorithm of each system unit and concomitant processes, and then to interconnect these models of system components in the form of digital computer programs so as to, in effect, represent the combined as well as the individual behavior of system components.

Table 5 (continued)

Type of Computer Use[b]	Name of Computer Program	Function of Computer Program	Source of Computer Program[a]		
			Program Written by:	Date of Original Development	Documentation
System Simulation	Hydraulic Submodel 2 (Water Surface Profiles, HEC-2)	Determine the stream surface profile commensurate with a given discharge by employing the standard step method of backwater computations in channel-floodplain reaches, and a special routine for bridges and culverts	U.S. Army Corps of Engineers, Hydrologic Engineering Center	February 1972	U. S. Army Corps of Engineers, Hydrologic Engineering Center, "HEC-2, Water Surface Profiles," Computer Program 723-X6-L202A, February 1972
	Hydrologic Submodel, Hydraulic Submodel 1, and Water Quality Submodel. (Hydrocomp Simulation Programming)	Continuous simulation of hydrologic, hydraulic, and water quality processes in the rural and urban portions of the watershed	Department of Civil Engineering, Stanford University, and Hydrocomp, Inc.	July 1966	"Digital Simulation in Hydrology: Stanford Watershed Model IV," Technical Report No. 39, of Civil Engineering, Stanford University, July 1966; "Hydrocomp Simulation Programming Operations Manual," Hydrocomp, Inc., Fourth Edition, January 1976; and "Hydrocomp Simulation Programming: Mathematical Model of Water Quality Indices in Rivers and Impoundments," Hydrocomp, Inc.
	Flood Economics Submodel	Calculate flood damages and cost of: structure floodproofing and removal, channelization, and dikes and floodwalls	SEWRPC	December 1973	SEWRPC files

[a] *Regardless of their original source, the computer programs described in this table were operated by the Commission staff on the SEWRPC computer system, and documentation is available in SEWRPC files.*

[b] *In addition to the indicated types of computer utilization, extensive use was made, under the Menomonee River watershed planning program, of existing SEWRPC data files containing natural resource and man-made features such as soils, land use, and population.*

Source: SEWRPC.

Pertinent information about each of the three computer programs used to simulate the hydrologic, hydraulic, and water quality units and processes as well as flood economics in the Menomonee River watershed is summarized in Table 5. These computer programs, one of which was developed by Hydrocomp, Inc., one by the U. S. Army Corps of Engineers, and one by SEWRPC, were used extensively during the analysis, forecast, and plan testing phases of the watershed planning program, and it is anticipated that they will be used during the implementation phase of the Menomonee River watershed planning program.

Economic Evaluation

The concepts of economic analysis and economic selection are vital to the public planning process. Sound economic analysis of benefits and costs should be an important guide to planners and decision-makers in the selection of the most suitable plan from an array of alternatives. All decisions concerning monetary expenditures, either private or public, are implicitly based on an evaluation of benefits and costs. This is not to imply that a formal economic analysis is made before every expenditure. The process of decision itself, however, consists of a consideration of whether the benefit received would be worth the amount paid. Benefits are not necessarily accountable in monetary terms and may be purely intangible, but the very act of expending money (or resources) for an intangible benefit implies that the benefit is worth to the purchaser at least the amount spent.

In addition to the consideration involved in deciding that a potential benefit is worth its cost, consideration is also given to possible alternative benefits that could be received for alternative expenditures within the limits of available resources. Alternative benefits are compared, either objectively or subjectively, and the one which is considered to give the greatest value for its cost is selected. Again, the benefits may be purely intangible; but the decision-making process itself implies an evaluation of which alternative is considered to be worth the most. When consideration is made of investment for future benefits, one alternative that should always be considered is the benefit which could be received from investment in the money market. This benefit is expressed in the prevailing interest rate.

Personal and private decisions, while implying at least subjective consideration of benefits and costs, broadly defined, are not necessarily based upon either formal or objective evaluation of monetary benefits and costs. Public officials, however, have a responsibility to evaluate objectively and explicitly the monetary benefits and costs of alternative investments to assure that the public will receive the greatest possible benefits from limited monetary resources.

It is, then, a fundamental principle that every public expenditure should desirably return to the public a value at least equal to the amount expended plus the interest income foregone from the ever-present alternative of public investment. This principle may also be stated that the public should receive a value return from its tax investment at least equal to what it could receive from private investment.

Therefore, economic analysis is a fundamental requirement of responsible public planning; and all plans should desirably promise a return to the public at least equal to the expenditure plus interest. It is emphasized that public expenditures should not be expected to "make money," but that they should be expected to return a value in goods, services, and environmental quality which is worth to the public the amount expended plus interest.

Benefit-Cost Analysis: The benefit-cost analysis method of evaluating government investments in public works came into general use after the adoption of the Federal Flood Control Act of 1936. The Act stated that waterways should be improved "if the benefits to whomsoever they may accrue are in excess of the estimated costs." Monetary value of benefits has since been defined as the amount of money which an individual would pay for that benefit if he were given the market choice of purchase. Monetary costs are taken as the total value of resources used in the construction of the project.

In order to assure that public funds are committed and expended wisely, alternative plan elements should be formulated, developed, and analyzed, and the recommended plan should be selected from those alternatives which meet watershed development objectives only after consideration of the following hierarchy of economic considerations:

1. Benefits, including intangible values, must exceed costs in order for a project to be economically justified.

2. An excess of benefits over costs, however, is not a sufficient criterion on which to base a watershed plan recommendation; and, therefore, among those alternative plan elements exhibiting benefit-cost ratios greater than one, the alternative with the greatest difference between benefits and costs, not the greatest benefit-cost ratio, will produce the largest absolute return on the investment.

3. Maximization of benefits minus costs is not, however, in and of itself a sufficient criterion for selection among alternative plan elements, since the amount of public funds available or potentially available, and public attitudes toward and understanding of a particular plan element, must be considered in selecting among various plan elements, and since it may be politically and financially impossible to obtain support and funding for a plan element even though it, among all the available alternatives, would produce the greatest return on the investment.

Implementation of comprehensive plans for the Menomonee River watershed could include benefits of floodland management; recreation; efficient community utilities and facilities; enhancement of property values; and recreational, scenic, cultural, and ecological values. Costs which could be incurred in implementation of watershed plans include construction, land acquisition, and income foregone as a result of regulation of land use.

There may be situations in which a local community affected by an alternative plan proposal subjectively evaluates the costs and benefits of that proposal in a manner differing significantly from an objective, economically sound analysis of the costs and benefits. The community may, for example, because of its subjective interpretation of benefits and costs, strongly favor an alternative plan proposal that has an objectively determined benefit-cost ratio of less than one; or, conversely, the affected community may oppose an alternative with a favorable benefit-cost ratio. Adoption and implementation of areawide plan elements with objectively determined benefit-cost ratios of less than one should generally be discouraged, except possibly in situations where the costs are borne entirely and equitably by, and with the full knowledge and understanding of, the local beneficiaries.

Time Value of Money—Interest: The benefits and often the costs of construction projects accrue over long periods of time. Each project or alternative, public and private, is likely to have a different time flow of benefits and costs. Benefits of one project may be realized earlier than those of another, while the time flow of costs may vary from one large initial investment for one project to small but continuously recurrent expenditures for another. In order to place these projects with varying time flows of benefits and costs on a comparable basis, the concept of the time value of money must be introduced.

A dollar has a greater value to the consumer today than does the prospect of a dollar in the future. Because of this time preference for money, a consumer will agree to pay more than one dollar in the future for one dollar today. Similarly, to an investor, one dollar in the future is worth less than one dollar today because he can obtain one dollar in the future from the investment of less than one dollar today. By the same reasoning, for public projects a one dollar cost or a one dollar benefit at some time in the future has a value of less than one dollar today. The variation of value of capital, benefits, and costs with respect to time is expressed through the mathematics of compound interest.

Use of an interest rate automatically incorporates consideration of the ever-present possibility of private investment as an alternative. Low interest rates tend to yield favorable benefit-cost analyses, whereas high interest rates tend to render projects uneconomic, particularly those alternatives that involve immediate capital expenditures to achieve a stream of benefits extended over a long period of time.

To be economical, a project should return to the public a benefit approximating that which might be obtained through private investment. Money invested privately is currently expected to return generally from 4 to 8 percent interest after taxes. Since implementation of the watershed plan should return benefits to the public similar to those which could be attained through private investment, an interest rate of 6 percent is recommended for use in the economic evaluation of plans. The 6 percent interest rate also approximates the current cost of money for public works projects.

The benefit-cost analysis for a project must be based on a specified number of years, usually equal to the physical or economic life of the project. Most of the improvements proposed in the Menomonee River watershed plans, however, will continue to furnish benefits for an indefinite time, particularly in the land use control and park reservation elements. In indefinite situations such as this, government agencies have generally selected 50 years for the period of economic analysis and this period is recommended for the Menomonee River watershed alternative plans.

Using 6 percent interest, benefits accrued after 50 years, when discounted to the present, are very small. For example, given a uniform annual benefit of one dollar, the total present worth of the entire 50-year period, from year 51 through year 100, would be only one dollar. The total present worth of the benefits for the 50-year period, from year one through 50, however, would be almost $16.

A final reason for using a 50-year period as a basis for benefit-cost analysis is the inability to anticipate the social, economic, and technological changes which may occur in the more distant future and which may influence project benefits and costs.

Project Benefits: The benefits from a project can be classified as tangible, or measurable in monetary terms, and intangible. Intangible benefits either are of such a nature that no monetary value can be assigned to them, or are so obscure that calculation of the monetary value is impracticable. In the Menomonee River watershed planning studies, tangible benefits include flood damage reduction, enhancement of property values, and those parts of recreation and water quality management to which a monetary value can be assigned. Intangible benefits include aesthetic factors deriving from natural beauty and a pleasant environment. Intangibles also include benefits, such as improved efficiencies in community utilities and facilities, that have monetary values but which are impracticable to calculate. The exact procedures used to compute benefits commensurate with alternative plans are discussed later in this report in conjunction with the description of alternative plan synthesis and testing.

Project Costs: The direct costs of water resource development include the construction costs of physical elements of the plan; the cost of acquiring land; plus expenditures for engineering, legal work, and project administration. Costs of structural facilities were calculated using 1975 unit prices, which reflect the magnitude of work, the location in the urban region, and regional labor costs.

The cost of land acquisition was based on 1975 market prices for urban improved, urban unimproved, and rural agricultural land in the Menomonee River watershed.

Relationship of Economic and Financial Analysis: The distinction between economic feasibility and financial feasibility is of particular importance in the consideration of the costs of land already under public ownership. A financial analysis involves an examination of the liquidating characteristics of the project from the point of view of the particular government agency undertaking the project. The relevant matters are the monetary disbursements and monetary receipts of the project. The financial analysis determines whether or not the prospective available funds are adequate to cover all of the costs.

On the other hand, an economic analysis by a government body determines if the project benefits to whomsoever they accrue exceed the costs to whomsoever they accrue. Since one of the legitimate objectives of government is to promote the general welfare, it is necessary to consider the effect of a proposed project on all of the people who may be affected, not just on the income and expenditures of a particular agency. The economic valuation of the benefits and costs may differ considerably from the actual income and expenditures of a government agency. The present market value of publicly owned by uncommitted land, such as the undeveloped holdings of a park commission, is counted on the cost side of the economic analysis. Under the economic criterion of benefits and costs to whomsoever they accrue, this land must be considered to have an economic value for alternative uses which is foregone when the land is committed to another use, such as open space or recreation. The costs of public lands already developed with facilities for recreation are considered as sunk costs and are not included in the economic analysis because alternative uses of the land can no longer be reasonably considered. The costs of land under public ownership, undeveloped or developed, are not considered in the financial analysis, since no monetary outlay is required.

Staged Development: An attractive feature of many water resource developments is their divisibility into several individual projects which may be financed and built at different times. Staged construction requires lower initial capital investments, reduces interest costs, and allows for flexibility of continued planning. Staging developments may also allow deferring an element until increased demands raise its benefit-cost ratio. In planning for staged development, however, consideration must be given to possibilities of higher costs in the future and the possible unavailability of land. In any development, staging also serves to lower risks incurred through unavailability of data during preparation and partial implementation of initial plans.

SUMMARY

The process 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 and watershed development plans must advance development proposals which are physically feasible, economically sound, aesthetically pleasing, and conducive to the promotion of public health and safety. Agreement on development objectives beyond such generalities, however, becomes more difficult to achieve because the definition of specific development objectives and supporting standards inevitably involves value judgments. Nevertheless, it is essential to state such objectives for watershed planning purposes and to quantify them insofar as possible through standards in order to provide the framework within which watershed plans can be prepared.

Moreover, so that the watershed plans will form an integral part of the overall long-range plans for the physical development of the Region, the watershed development objectives must be compatible with, and dependent upon, regional development objectives, while meeting the primary watershed development objectives. Therefore, the watershed development objectives and supporting principles and standards set forth herein are based upon, and incorporated in, previously adopted regional development objectives, supplementing these only as required to meet the specific needs of the Menomonee River watershed planning program. The adopted development objectives for the Menomonee River watershed plan consist essentially of six of nine previously adopted regional land use planning objectives, three of four recently adopted regional sanitary sewerage system planning objectives, and three of four water control facility objectives adopted under earlier Commission comprehensive watershed planning studies.

In addition to presenting and discussing the objectives, principles, and standards adopted for the Menomonee River watershed, this chapter also presented the engineering design criteria and analytic procedures used in the watershed study. These criteria and procedures were used to synthesize a Menomonee River watershed plan capable of meeting the study objectives, and were applied in the inventory and analysis of data, in the synthesis and testing of alternative plan subelements, and in making economic comparisons between those subelements.

The selected design criteria and analytic procedures include watershed rainfall intensity-duration-frequency relationships, recommended storm sewer design procedures, a flood discharge-frequency analysis technique, and selection of the design flood for the floodland management element of the watershed study. Digital computer utilization and economic evaluation are also discussed in this chapter inasmuch as they relate to important analytic procedures utilized in the preparation of the watershed plan.

Chapter III

LAND USE BASE AND ALTERNATIVE NATURAL RESOURCE PROTECTION MEASURES

INTRODUCTION

The economic and demographic base and the existing land use pattern of the Menomonee River watershed were described in Chapter III, Volume 1, of this report. Forecasts of probable future population and economic activity levels, together with accompanying demands for various land uses within the watershed, were set forth in Chapter IV, Volume 1, of this report. The resident population of the watershed was forecast to increase from the 1970 level of about 348,000 to a year 2000 level of about 388,000 persons, an increase of about 12 percent in approximately 30 years. Employment within the watershed was forecast to increase from the 1972 total of about 170,600 jobs to a year 2000 total of about 218,800 jobs, an increase of about 28 percent.

In the face of this growth in population and employment the amount of land devoted to urban use within the watershed was projected to increase from the 1970 total of about 73 square miles, or about 54 percent of the total area of the watershed, to 90 square miles, or about 66 percent of the total area of the watershed, by year 2000 (see Chapter IV, Volume 1). This demand for urban land will have to be satisfied primarily through the conversion of some of the remaining agricultural lands, woodlands, and wetlands of the watershed from rural to urban uses. Such rural land uses may be expected to decline collectively from about 63 square miles in 1970 to 46 square miles in the year 2000, a decrease of about 28 percent. It is extremely important that the new urban development be related sensibly to soil capabilities; to long established utility systems; to the floodlands of the Menomonee River system; and to the wetlands, woodlands, and surface water resources of the watershed. If such new urban development is not so related, the already severe developmental and environmental problems of the watershed, as documented in Volume 1, of this report, may be expected to continue to intensify.

If such intensification of developmental and environmental problems is to be avoided and the serious problems of flooding and water pollution already existing within the Menomonee River watershed are to be abated, new urban development within the watershed must be directed into a more orderly and efficient pattern, a pattern carefully adjusted to the ability of the underlying and sustaining natural resource base to support further urban development. A land use plan, therefore, must constitute a major element of any comprehensive plan for the development of the Menomonee River watershed. This land use plan element, although emphasizing protection of the riverine areas and of the recreational resource base of the watershed, must cover the entire watershed and must represent the major basic approach to resolution of the growing environmental and developmental problems of the watershed. Structural water control facility plan elements for flood control and pollution abatement must be subordinate to and support the land use plan element in that the structural water control facility plan elements do not affect the entire watershed and cannot alone offer sound solutions to the developmental and environmental problems of the watershed.

This chapter presents a brief description of the necessary basic land use plan element, with particular attention to the alternatives available for protecting the natural resource base of, and the overall quality of the environment within, the watershed as a whole.

LAND USE BASE

Design Methodology

As noted above, the land use plan forms the basic element of the comprehensive watershed plan. A land use plan for a watershed within an urbanizing region must be set within the framework of an areawide—or regional—land use plan. A regional land use plan was adopted by the Commission in 1966. Due to the attainment of additional knowledge of the Region since that time, the formation of additional development objectives under other related regional and subregional planning programs, and both adverse and favorable public reaction to plan implementation proposals, it was deemed essential to properly reevaluate the adopted regional land use plan, which had a design year of 1990, and update that plan to the year 2000. This plan reevaluation effort was conducted by the Commission concurrently with the Menomonee River watershed study.

Accordingly, the watershed land use plan recommended herein is set within the context of, and reflects the concepts contained in, the revised and updated regional land use plan for the year 2000.[1] The new regional land use plan, which is documented in full in SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000, Volume Two, Alternative and Recom-

[1] *The data set forth herein pertaining to the new regional land use plan for 2000 represent a version of that plan presented at a regional planning conference on April 14, 1976. The final version of that plan, documented in SEWRPC Planning Report No. 25, Volume 2, does not differ from the plan presented herein in any significant respect.*

mended Plans, like the initial regional land use plan, places great emphasis on centralization of development, with virtually all new urban development proposed to be located in areas served by centralized public sanitary sewerage and water supply facilities.

Thus, the recommended general land use pattern for the Menomonee River watershed plan was basically established by the preparation of the revised and updated regional land use plan for the year 2000. The regional land use development objectives which this regional land use plan is designed to meet are set forth in the aforereferenced SEWRPC Planning Report No. 25, Volume 2, and remain valid and attainable within the context of the more detailed watershed development plan. Therefore, these revised regional development objectives and the supporting principles and standards were made the basis of the watershed land use development objectives, principles, and standards as set forth in Chapter II of this volume.

The revised and updated regional land use plan sets forth broad recommendations for areawide land use development designed to meet the social, physical, and economic needs of the Region while protecting and enhancing the natural resource base. The resolution of the specific natural resource-related problems existing within the Menomonee River watershed, as set forth in Chapter IX, Volume 1, of this report, however, requires more intensive land use investigation, more detailed land use plan design, and more specific land use plan implementation recommendations, particularly with respect to the riverine areas of the watershed, in order that the developmental and environmental problems of the watershed may be abated through appropriate private, as well as local, state, and federal governmental actions. Therefore, this chapter, in addition to describing the revised regional land use plan as it applies to the Menomonee River watershed, sets forth three detailed alternative proposals for the wise use of the natural resources of the watershed in order to achieve a favorable natural environment through fuller realization of the aesthetic, ecologic, educational, and recreation-related values of the resource base.

The primary environmental corridor has been identified in the inventories and analyses conducted under both the regional land use and watershed planning efforts as an important feature of the natural resource base requiring protection through sound land use development and management. Accordingly, three specific alternative plans for the preservation of the primary environmental corridor are presented in this chapter. In these alternative plans, specific attention is given to the preservation of the following components of the primary environmental corridors: the streams and the associated floodlands, shorelands, wetlands, woodlands, and wildlife habitat areas. It should be noted in this respect that, unless specified to the contrary, the areal extent of the woodland, wetland, and wildlife habitat areas proposed to be protected and preserved under the various alternative plans are based upon the detailed data compiled for the Commission by the Wisconsin Department of Natural Resources under the watershed planning program and presented in Chapter IX, Volume I, of this report.

Land Use Base Description

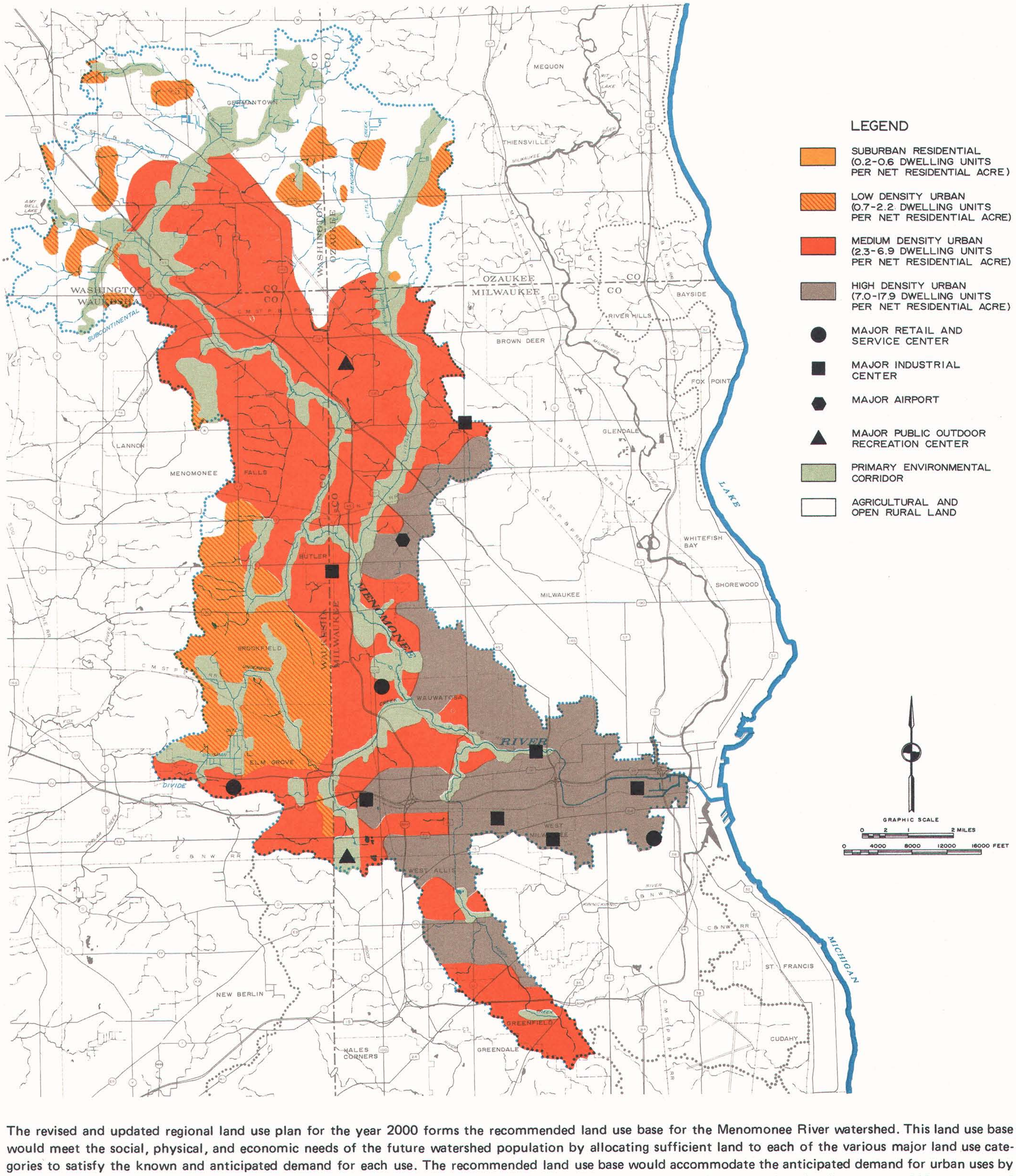
As already noted, the revised and updated regional land use plan for year 2000 forms the recommended land use base for the Menomonee River watershed plan. This recommended land use base would meet the social, physical, and economic needs of the future watershed population by allocating sufficient land to each of the various major land use categories to satisfy the known and anticipated demand for each use, meeting both the demands of the urban land market and the land use plan design standards developed for the revised and updated regional land use plan. Under the recommended regional land use plan, the allocation of the future land uses within each county of the Region is such as to meet the demand for land which may be expected to be created by the forecast population growth within each county through the plan design year 2000. To the extent possible, the proposals contained in existing community development plans and ordinances are accommodated in the land use base. The land use base seeks to protect and enhance the natural resource base of the Region and the watershed and allocates new urban development only to those areas of Region and watershed that are covered by soils well suited to such development. It further seeks to encourage urban development in those areas of the watershed that can be readily provided with gravity drainage sanitary sewer service and public water supply.

The land use base emphasizes continued reliance on the urban land market to determine the location, intensity, and character of future development within the Region and the watershed for residential, commercial, and industrial land uses. It does, however, propose to regulate in the public interest the effect of this market on development in order to provide for a more orderly and economical land use pattern and in order to avoid intensification of developmental and environmental problems within the Region and the watershed. This land use base is shown in graphic summary form on Map 2 and is more specifically described in the following paragraphs and subsequent sections of this chapter. It is important to note that the recommended land use base would accommodate the anticipated demand for urban land uses through the conversion of about 15 square miles of land to urban use by 2000, or two fewer than the projected conversion of 17 miles under unplanned conditions as noted above.

It is important to note that the land use base, as shown on Map 2, represents a refinement of the adopted revised and updated regional land use plan for the year 2000 in the riverine areas of the watershed. This plan refinement was primarily directed at delineating the boundaries of the primary environmental corridors within the watershed and was made possible by the woodland, wetland, and wildlife habitat inventories and the floodland delineations carried out as part of the Menomonee River watershed study. These data

Map 2

RECOMMENDED LAND USE BASE FOR THE MENOMONEE RIVER WATERSHED: 2000



The revised and updated regional land use plan for the year 2000 forms the recommended land use base for the Menomonee River watershed. This land use base would meet the social, physical, and economic needs of the future watershed population by allocating sufficient land to each of the various major land use categories to satisfy the known and anticipated demand for each use. The recommended land use base would accommodate the anticipated demand for urban uses by conversion of about 15 square miles of land to urban use by the year 2000. Under the recommended land use plan, new urban development would be encouraged to occur contiguous to and outward from existing urban development in areas covered by soils suitable to such use and readily provided by sanitary sewer, public water supply, mass transit, and other essential urban services. Medium population density levels would be stressed for the bulk of the new development occurring in the middle portions of the basin. Under the plan no new urban development would be permitted in flood hazard areas or in the primary environmental corridors and prime agricultural areas of the watershed.

Source: SEWRPC.

were used to refine the corridor boundaries as those boundaries were originally delineated in the new regional land use plan.

Residential Land Use: As indicated in Table 6, the land use base proposes to add about eight square miles to the existing stock of residential land in the watershed between 1970 and 2000 in order to supply land to meet the housing needs of the anticipated population increase, an increase of 24 percent in such lands. All new urban development would occur at medium population densities, with lot sizes ranging from approximately 6,000 square feet to about one-half acre per dwelling unit and with gross residential population densities ranging from 3,500 to 10,000 persons per square mile.

In 1970, about 84 percent of the urbanized area of the watershed and about 89 percent of the total watershed population were served by public sanitary sewerage facilities; and about 77 percent of the urbanized area of the watershed and 85 percent of the total watershed population were served by public water supply systems. By the year 2000, essentially all of the urban areas within the watershed are proposed to be served by public sanitary sewerage and public water supply facilities with the exception of park and recreation lands and small scattered low-density residential areas in the headwaters of the Menomonee River.

Retail and Service Land Use: Three major or regional commercial centers exist wholly or partly in the watershed—Mayfair in the City of Wauwatosa, Brookfield Square in the City of Brookfield, and Mitchell Street in the City of Milwaukee. Based upon the revised and updated regional land use plan for the year 2000, no new regional retail and service centers are proposed for the watershed. Approximately 0.28 square mile of new community and local retail and service land would be added during the plan design period. As shown in Table 6, these additions to the existing stock of retail and service land in the watershed would result in a year 2000 total of about two square miles, or an increase of nearly 16 percent over the existing area of such land.

Industrial Land Use: The number of industrial employment opportunities, or jobs in manufacturing and wholesaling industries, may be expected to increase by about

Table 6

EXISTING AND PROPOSED LAND USE IN THE MENOMONEE RIVER WATERSHED 1970 AND 2000 RECOMMENDED LAND USE PLAN

Land Use Category	Existing 1970			Planned Increment		Total 2000		
	Square Miles	Percent of Major Category	Percent of Watershed	Square Miles	Percent Change	Square Miles	Percent of Major Category	Percent of Watershed
Urban Land Use								
Residential								
Urban High Density	9.09	12.6	6.7	- .02	- 0.2	9.07	10.4	6.7
Urban Medium Density	9.38	13.0	6.9	10.03	106.9	19.41	22.2	14.3
Urban Low Density	14.49	19.9	10.7	- 1.59	- 11.0	12.90	14.7	9.5
Suburban Density	0.93	1.2	0.7	- 0.40	- 43.0	0.53	0.6	0.4
Subtotal	33.89	46.7	25.0	8.02	23.7	41.91	47.9	30.9
Commercial	1.77	2.4	1.3	0.28	15.8	2.05	2.3	1.5
Industrial[a]	3.82	5.3	2.8	1.23	32.2	5.05	5.8	3.7
Governmental and Institutional	5.02	6.9	3.7	0.65	12.9	5.67	6.5	4.2
Transportation, Communication, and Utilities	22.22	30.7	16.4	4.33	19.5	26.55	30.3	19.6
Recreation	5.79	8.0	4.3	0.49	8.5	6.28	7.2	4.6
Urban Land Use Subtotal	72.51	100.0	53.5	15.00	20.7	87.51	100.0	64.5
Rural Land Use								
Residential	- -	- -	- -	- -	- -	- -	- -	- -
Agriculture	45.19	71.6	33.3	- 11.39	- 25.2	33.80	70.2	24.9
Other Open Lands	17.93	28.4	13.2	- 3.61	- 20.1	14.32	29.8	10.6
Rural Land Use Subtotal	63.12	100.0	46.5	- 15.00	- 23.8	48.12	100.0	35.5
Total	135.63[b]	- -	100.0	- -	- -	135.63	- -	100.0

[a] *Includes manufacturing, wholesaling, storage, and quarries.*

[b] *This figure represents the total area of the watershed as determined through approximating the watershed boundary by U. S. Public Land Survey quarter sections and summing the quarter section totals.*

Source: SEWRPC.

20,600 jobs, from about 73,100 jobs in 1972 to about 93,700 jobs in the year 2000, an increase of about 28 percent. Rising levels of economic activity within the watershed are anticipated to result in an increasing demand for industrial land. However, based on the revised and updated regional land use plan for the year 2000, there would be no new major industrial centers provided in the land use base for the watershed. Industrial activity in the watershed would continue to be concentrated in the seven existing major industrial centers: three centers in the City of Milwaukee—the Menomonee River Industrial Valley—East, the Menomonee River Industrial Valley—West, and the Milwaukee Industrial Land Bank in the former Town of Granville; two centers in the City of West Allis—West Allis East and West Allis West; one center in the Village of West Milwaukee; and one center in the Village of Butler. Approximately 1.2 square miles of new industrial land are proposed to be provided in the revised and updated regional land use plan, to be added to the existing 3.82 square miles of manufacturing and mining, wholesale, and storage land use in the watershed, an increase of 32 percent.

The Department of City Development of the City of Milwaukee is currently involved in an Overall Economic Development Program (OEDP) for the City of Milwaukee, the main thrust of which is a revitalization program for the Menomonee River Industrial Valley.[2] Possible program elements include: 1) the establishment of a regional recycling center—currently being constructed on Mt. Vernon Avenue—which will serve southeastern Wisconsin waste disposal needs and simultaneously act as a magnet to draw additional resource recovery, marketing, and recycling firms into the Valley area; 2) the establishment of industrial park districts in suitable parts of the Valley area; 3) the general upgrading of infrastructure, land use patterns and visual amenities, including improvements in street lighting, street paving, sewerage and water supply and landscaping and refurbishing programs; and 4) improving access to the floor of the industrial valley by construction of new bridges and roads or by improving existing facilities.

Transportation, Communication, and Utility Facility Land Use: As indicated in Table 6, the land use base proposed to add approximately 4.3 square miles of transportation, communication, and utility facility land use, or an increase of nearly 20 percent, to the existing stock of such land uses within the watershed.

Government and Institutional Land Use: As also indicated in Table 6, the land use base would add approximately 0.7 square miles of governmental and institutional land use, or an increase of about 13 percent, t the existing stock of such land uses within the tershed.

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[2] *"A Prospectus—Menomonee Valley Redevelopment Area-Generic Environmental Impact Model," Milwaukee Department of City Development, December 1975.*

Agricultural Land Use: The previously described increases in urban land uses in the watershed by the year 2000 would result in a corresponding decrease in agricultural and other rural and related open-space uses. The existing stock of rural land within the watershed could, therefore, be expected to decrease from 63 square miles in 1970 to 48 square miles in the year 2000, a decrease of nearly 24 percent.

Other Land Uses: The land use base also includes proposals for the preservation of the primary environmental corridors and for the reservation and development of outdoor recreation and related open-space lands. These lands will be described in greater detail in the following sections of this chapter.

ALTERNATIVE PRIMARY ENVIRONMENTAL CORRIDOR PROTECTION SUBELEMENTS

Primary Environmental Corridors

The concept of the environmental corridor, as well as a description of the key elements of an environmental corridor, was set forth in Chapter III, Volume 1, of this report. Floodlands, a key element in corridor delineation, were described in Chapter V, Volume 1, whereas woodlands-wetlands and wildlife habitat—two other important corridor elements—were described in detail in Chapter IX, Volume 1. This section of the chapter reviews the values of primary environmental corridors, describes the procedure used to delineate the corridors in the Menomonee River watershed, and discusses alternative means of preserving the primary environmental corridors for the protection of the best remaining elements of the natural resource base, including the wildlife habitat areas, woodland-wetlands, streams and associated floodlands, as well as the best remaining potential park and related open-space sites, including high-value historic, scientific, and scenic sites within the watershed.

Corridor Values: As discussed in greater detail in Chapter IX, Volume 1 of this report, the watershed streams, woodlands-wetlands, and wildlife habitat areas, in addition to providing a setting for outdoor recreational activities, possess aesthetic value and perform important ecological and educational functions. Although the urbanizing Menomonee River watershed contains, with a few exceptions, only remnants of important natural resource elements, those remnants when integrated into a network of primary environmental corridors have the potential to substantively contribute to the stability of the ecosystem and the quality of life in the watershed.

Historic sites and structures, although not a part of the natural resource base, are closely related to and contribute to the value of the primary environmental corridor. Remnants of historic places and events—mills, churches, inns, covered bridges—tend to be concentrated in the corridors because there was considerable motivation for development in riverine areas by early settlers. Comprehensive watershed planning can help to preserve and even restore many significant historic sites and the cultural record and educational values inherent in such sites by urging compatible, contiguous open space uses which may result when the historic sites are included with those portions of the environmental corridor designated for protection.

The environmental corridor concept is partly founded on the unsuitability of riverine areas for urban development as demonstrated by historic flood damages in the watershed attributable to floodland development and by the limitations of riverine area soils for urban development. Furthermore, urbanization of floodlands is simply not needed to meet the existing or forecast living and working space requirements of the resident population of the watershed nor of the Region of which the watershed is an integral part. Future populations can be readily accommodated at acceptable densities without occupying floodlands and adjacent environmental corridor lands.

Corridor Delineation: Inasmuch as the primary environmental corridor is a composite of up to 11 of the natural resource-related elements, the identification of those areas of the watershed having the requisite three or more of the 11 elements is a difficult task. The corridor delineation process is further complicated by the four-level value rating assigned to the woodland-wetland and wildlife habitat components of the corridor. Identification of the primary environmental corridors in the Menomonee River watershed was accomplished with the assistance of the Land Data Management System (Land DMS) developed by the Commission staff,[3] and is operable on the Commission computer system. The Land DMS is described below followed by a discussion of its use in the watershed study.

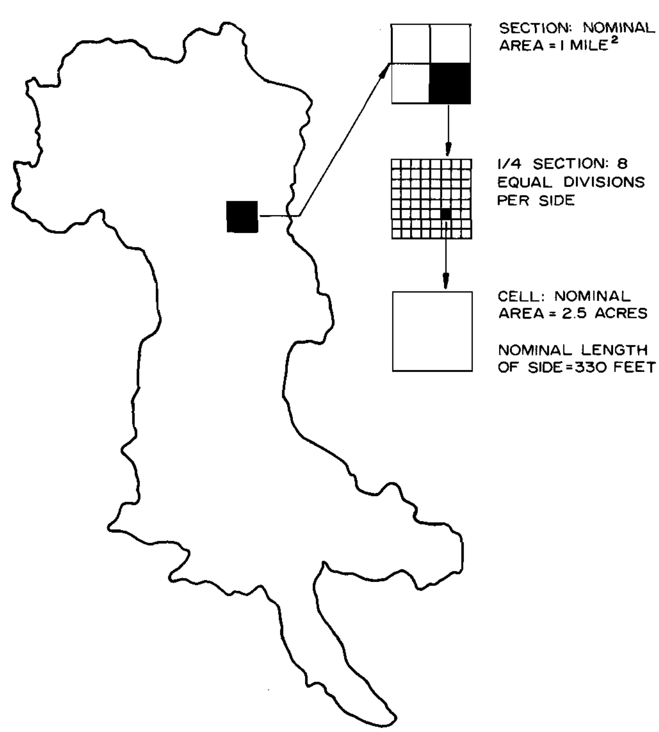
Description of the Land Data Management System: The Land Data Management System (Land DMS) is a digital computer-based system designed to store, retrieve, analyze and display land data in tabular or graphic form. The term "land data" as used in the context of the Land DMS is a comprehensive concept in that it denotes all those watershed characteristics that have an areal extent. For example, land data encompasses land use, soil type, and civil division information but does not include water quality or streamflow data.

Data Storage Unit—The Cell: The basic areal unit for storing retrieving, analyzing, and displaying land data is the cell. The cell approach was selected over the area boundary alternative because the cell mode is more technically and economically feasible for the effort required to code areal data from primary sources and for the computer programming and computer storage required to manipulate and interpret the data, including the use of overlay and weighing techniques. The Menomonee River watershed was subdivided into about 35,000 cells by partitioning U.S. Public Land Survey system quarter sections as shown on Figure 2. More specifically, each of the four sides of each quarter section was equally divided into eight parts and the grid marks on opposite sides of the quarter section were connected resulting in 64 cells per quarter section, each having a nominal area of 2.5 acres. The use of cells that are partitions of quarter sections has one principal advantage: It facilitates the geo-referencing of each cell since horizontal survey control has been established by the Commission and by local units of government to Commission standards for a large number of quarter section corners in the watershed using field survey methods. That control was directly transferable, by computation, to the centers and corners of each cell.

Geo-referencing: An accurate geo-referencing arrangement is required to permit computation of the area of each cell or of groups of cells and to facilitate display, in map form, of selected land data. The corners of each cell were accordingly referenced to the State Plane Coordinate System. The best available sources of information were used to first determine the State Plane Coordinates of the corners of each quarter section contained wholly or partly in the Menomonee River

Figure 2

THE CELL: BASIC AREAL UNIT IN THE LAND DATA MANAGEMENT SYSTEM USED TO IDENTIFY PRIMARY ENVIRONMENTAL CORRIDORS IN THE MENOMONEE RIVER WATERSHED



Source: SEWRPC.

[3] *The Land DMS was developed by the SEWRPC staff for the International Joint Commission's Menomonee River Pilot Watershed Study which was conducted coincident with the Menomonee River watershed planning program.*

watershed. Plane geometry was then used to calculate, within the Land DMS, the State Plane Coordinates of each cell.[4] The coordinates of the cell corners were then used to calculate the area of the approximately 35,000 cells in the Menomonee River watershed. The cells range in size from 2.18 to 2.97 acres and have an average area of 2.52 acres.

The Supporting Computer System: The digital computer system—hardware and software—needed to support the Land DMS can be broken into four phases: the input phase, the data management phase, the data base phase, and the output phase. Under the input phase, data are entered into the Land DMS on either magnetic diskettes or punched cards. The second or data management phase is composed of a set of computer programs that perform contingency checks on the incoming data, provide for the maintenance and updating of the Land DMS, analyze the data and transfer it—on request—back to the user. The analysis capability of the data management phase facilitates the identification of cells having specified combinations of land data types—a necessary feature for corridor delineation. The third or data base phase of the Land DMS is the actual storage of the areal characteristics of each cell in a computer file, maintained on magnetic tape or on a magnetic disc. The data base may be viewed as a large file cabinet with many drawers where each drawer corresponds to a cell and each of the file folders within each drawer corresponds to each of the types of areal data on file in the Land DMS. The fourth or output phase provides, under control of the data management phase, transfer of land data from the Land DMS to the user in a variety of formats. For example, land data can be output on a cell basis or aggregated by civil division or some other geographic area of interest. System output can be obtained on several media including magnetic tape, punched cards, on-line printer, and plotter.

Land Data Contained in the Land DMS: The Land DMS as developed for the Menomonee River watershed contains a large number of land data types; however, only those data types set forth in Table 7 were required in the corridor delineation process and need be discussed here. Each of the five data types appearing in the table was coded by cell on a dominant basis. For example, if half or more of a cell were covered by floodland, the entire cell was coded as floodland; if less than half the cell were covered by floodland, the cell was coded as containing no floodland. Woodland-wetland data and wildlife habitat data were coded with respect to value ratings as described in Chapter IX of Volume 1 of this report. Table 7 indicates the source of each of the data types and the medium from which the land data were extracted for input to the Land DMS.

[4] *The Land DMS can also readily convert the cell corner coordinates to other geo-referencing systems such as latitude and longitude and the Universal Transverse Mercator System.*

Application of the Land Data Management System: Use of the Land DMS to assist in the identification of primary environmental corridors in the Menomonee River watershed was initiated by subjectively assigning numerical values ranging from 1.0 to 1.5 for each of the five land data types listed in Table 7. This permitted a relative quantification of the value and significance of each land data type as well as subdivisions within those two data types for which descriptive value ratings had been established by the Wisconsin Department of Natural Resources.

Within the framework of cells, the basic objective in corridor delineation is to identify those cells containing three or more—or the equivalent of three or more—of the 11 natural and natural-resource related elements needed, by definition, to include the cell within the primary enviromental corridor. Using the numerical values assigned to each of the five land data types, each cell having a total of three or more points is within the primary environmental corridor, provided of course that there are sufficient contiguous cells to form a land unit of practicable size. A cell could qualify for inclusion if it contained three of the five elements or, in unusual cases, if it contained a combination of high value woodland-wetland and high value wildlife habitat in which case the total value would be three and the cell would be considered as equivalent to having three elements.

The Land DMS was programmed to determine the sum of the assigned numerical values for each cell in the watershed and to produce a map on which the point total was shown for each cell having one or more corridor elements.

The map generated by the Land DMS was manually supplemented with information relevant to the following five natural resource and natural resource-related elements pertinent to primary environmental corridor delineation: aesthetically pleasing area of rolling terrain and high relief topography, significant geological formations and physiographic features, potential outdoor recreation and related open space sites, historic sites and structures, and scenic areas and vistas. These remaining five elements of primary environmental corridors are not readily defined in terms of areal extent nor are they otherwise quantifiable and therefore their impact on the preliminary primary environmental corridor as mapped by the Land DMS was subjectively determined by the Commission staff. The practical effect of this subjective evaluation was to make small, localized adjustments to the corridor limits since these five natural resource and natural resource-related elements are relatively few in number and are scattered throughout the watershed.

The primary environmental corridor areas were further refined by adding contiguous cells that contain land in public and private outdoor recreation use, that were within the 100-year recurrence interval floodlands of the watershed, or that contained soils having severe and very severe limitations for urban development. These contiguous areas were added not only because they serve further to enhance the value of the total corridor by buffering the highest value portions of the corridor from the surrounding, more intensely used urban and rural land, but also because these areas generally cannot be converted to extensive urban use without creating serious environmental and developmental problems. This refinement had the effect of generally expanding the width of the environmental corridor and of producing a smoother more curvilinear boundary. The resulting primary environmental corridors are depicted on Map 3, and data on the area of the corridors is set forth in Table 8.

Table 7

LAND DATA IN THE LAND DATA MANAGEMENT SYSTEM USED TO DELINEATE AND QUANTIFY ENVIRONMENTAL CORRIDORS IN THE MENOMONEE RIVER WATERSHED

Data [a,b] Type	Data Source	Media from Which Data were Extracted for Input to Land DMS	Value Rating	
			Descriptive	Numerical
Floodlands—100 Year Recurrence Interval	Historic Flooding	Best available maps	- -	1.0[c]
Woodland—Wetland[d]	Wisconsin Department of Natural Resources Field Survey conducted for Commission under Menomonee River watershed planning program.	1" = 400' scale aerial photographs	High Value Good Value Moderate Value-Park way Moderate Value-Local	1.5 1.3 1.0 1.0
Wildlife Habitat	Wisconsin Department of Natural Resources Field Survey conducted for Commission under Menomonee River watershed planning program.	1" = 400' scale aerial photographs	High Value Good Value Moderate Value Low Value	1.5 1.3 1.1 1.0
Soils—Severe and Very Severe Limitations for Urban Development	SEWRPC-Soil Conservation Service regional soil survey	1" = 2000' scale soil maps	- -	1.0[e]
Existing Park and Outdoor Recreation Sites	SEWRPC regional park and open space planning program	1" = 2000' scale map	- -	1.0[d]

[a] Although not explicitly input to the Land DMS, the following nonquantifiable five factors also were considered in the delineation of the primary environmental corridors: rugged terrain and high relief topography, significant geological formations and physiographic features, potential outdoor recreation and related open space sites, historic sites and structures, and scenic areas and vistas.

[b] Although not explicitly used in the corridor delineation process, civil division data, land cost data, and selected zoning information were coded by cell to facilitate analysis of the results.

[c] Floodland information was not available for some perennial streams. In order to approximate the floodland status of such areas, a floodland value of 1.0 was assigned to each cell traversed in whole or in part by a perennial stream reach. For this reason, perennial stream reaches were coded by cell and used as input to the Land DMS.

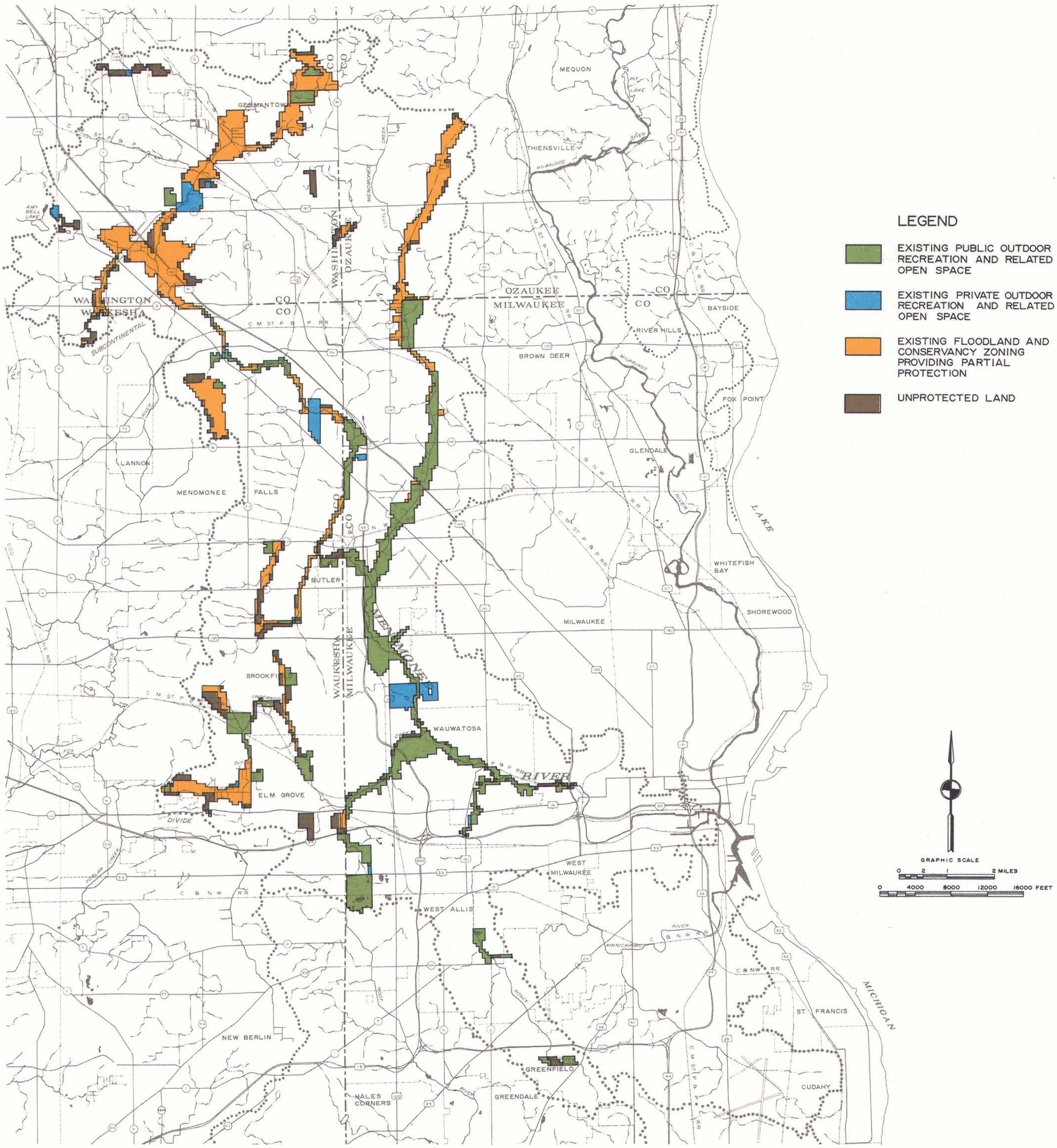
[d] Woodland-Wetland areas were not inventoried under the watershed study on public and private park and outdoor recreation sites. Therefore, all park and outdoor recreation sites were given a numerical value of 2.0, composed of 1.0 for the park and outdoor recreation site value and 1.0 for an assumed moderate value woodland-wetland.

[e] Soils data are not available for the lower 15 percent of the watershed. In order to account for the probable presence of soils with limitations for urban development in this area, each floodland cell located therein was assigned an extra value of 1.0 on the assumption that floodlands provide a first approximation of poor soils.

Source: SEWRPC.

Map 3

PRIMARY ENVIRONMENTAL CORRIDORS IN THE MENOMONEE RIVER WATERSHED: 1970



This map shows the primary environmental corridors of the Menomonee River watershed as delineated with the assistance of the Land Data Management System developed under the Menomonee River watershed planning program. Although the urbanizing Menomonee River watershed contains only remnants of important natural resource elements, those remnants when integrated into a network of primary environmental corridors have the potential to substantively contribute to the stability of the ecosystem and the quality of life in the watershed. A fundamental feature of primary environmental corridors is that while they encompass a relatively small portion of the watershed—16 square miles or 12 percent of the total area of the watershed—they include a large fraction of the remaining high value natural resource and natural resource-related features. For example, the primary environmental corridors as shown on this map encompass only 12 percent of the total area of the watershed but contain about 71 percent of the perennial stream channel length, 78 percent of all floodlands, 91 percent of all remaining woodland-wetland areas, 61 percent of all remaining wildlife habitat areas, and 60 percent of all existing outdoor recreational sites. Approximately 38 percent of the primary environmental corridor lands is in public ownership for outdoor recreation and related open space uses and another 7 percent in private ownership for similar uses. In addition, 41 percent of the primary environmental corridor lands is partially protected by floodland, conservancy, and other zoning that places some restrictions on incompatible use of the corridor lands. Therefore, about 86 percent of the primary environmental corridor lands in the Menomonee River watershed is presently subject to some form of permanent or interim protection.

Source: SEWRPC.

In addition to using the Land DMS to identify the basic structure of the primary environmental corridors, the Land DMS was used subsequently to identify, map, and quantify those portions of the corridor protected by various land use controls. The system also was used to calculate acquisition costs attendant to three alternative primary environmental corridor plan subelements and to prepare maps and tabular summaries of each of the plan subelements. The results of these applications of the Land DMS are presented later in this chapter.

Corridor Description: The primary environmental corridors of the Menomonee River watershed as delineated above encompass over 16 square miles, or approximately 12 percent of the total watershed area of 137 square miles. As shown on Map 3, the primary environmental corridors are rather uniformly distributed throughout the watershed, encompassing lands along the Upper Menomonee River and Lower Menomonee River; along the three major tributaries—the Little Menomonee River, Underwood Creek, and Honey Creek; and along five minor tributaries—the North Branch of Menomonee River, Willow Creek, Butler Ditch, Dousman Ditch, and the South Branch of Underwood Creek.

It is important to note that while the primary environmental corridors in the Menomonee River watershed form an essentially continuous system encompassing the high value elements of the natural resources base, that system also is related to and directly connected with primary environmental corridor lands in adjacent watersheds. For example, the primary environmental corridor lands along the Little Menomonee River extend across the watershed divide in the northeastern portion of the basin to connect with the primary environmental corridor located along the main stem of the Milwaukee River. Similarly, the primary environmental corridor encompassing the Tamarack Swamp in the watershed extends to and across the watershed divide to connect with the primary environmental corridor along the headwater of the Fox River. The primary environmental corridor system along the Dousman Ditch extends across the western divide of the watershed to connect with a primary environmental corridor in the Fox River watershed. The primary environmental corridor along the South Branch of Underwood Creek extends across the southern boundary of the watershed to merge with the primary environmental corridor located along the North Branch of the Root River in the Root River watershed. Finally, the small portion of the primary environmental corridor along the middle reaches of Honey Creek in the Menomonee River watershed connects with a primary environmental corridor in the Kinnickinnic River watershed.

Natural Resource Elements: Table 8 indicates the distribution of selected natural resource elements in the watershed and in the primary environmental corridor

Table 8

DISTRIBUTION OF SELECTED NATURAL RESOURCE ELEMENTS IN THE MENOMONEE RIVER WATERSHED AND IN THE PRIMARY ENVIRONMENTAL CORRIDORS WITHIN THE WATERSHED: 1970

Natural Resource Element	Acres		Percent In Corridor
	In Watershed	In Corridor	
Perennial Streams (Miles)	68.6	48.51	70.71
Floodlands (Acres)	5,233.93	4,066.15	77.69
Soils with Severe or Very Severe Limitations for Urban Development (Acres)	13,298.35	6,535.97	49.15
Woodlands and Wetlands (Acres)	2,748.03	2,506.47	91.21
High Value	83.64	83.64	100.00
Medium Value	1,023.33	1,015.77	99.26
Moderate-Parkway	1,147.48	1,029.43	89.71
Moderate-Local	493.58	377.63	76.51
Wildlife Habitat (Acres)	9,275.11	5,703.17	61.49
High Value	975.58	920.17	94.32
Good Value	2,760.28	1,593.41	57.73
Moderate Value	5,236.74	3,189.59	60.91
Low Value	302.51	0.0	0.0
Existing Outdoor Recreation Sites (Acres)	7,682.56	4,641.09	60.41
Public	6,472.58	3,959.52	61.17
Private	1,209.98	681.57	56.33

Source: SEWRPC.

itself. The corridor contains about 71 percent of the perennial stream channel length, about 78 percent of all floodlands, about 91 percent of all remaining woodland-wetland areas including 100 percent, and 99 percent, respectively, of the remaining high and medium value woodland-wetland areas. The primary environmental corridor also encompasses over 61 percent of all remaining wildlife habitat areas, including 94 percent of the high value wildlife habitat areas and about 60 percent of all existing outdoor recreational sites.

Distribution by Civil Division: Table 9 sets forth the distribution of the primary environmental corridor and of the natural resource elements comprising the primary environmental corridor by county, city, village, and town. The proportion of watershed primary environmental corridor located in Milwaukee, Ozaukee, Washington, and Waukesha Counties is, respectively, 36, 7, 29, and 29 percent. The Milwaukee County portion of the watershed contains the largest amount of floodlands—2,246 acres—and 1,744 acres, or 78 percent of those floodlands, are included in the primary environmental corridor. Washington County contains the greatest extent of soils having severe or very severe limitations for urban development—4,798 acres—and 2,544 acres, or 53 percent of those soils-limited acres, are within the primary environmental corridor. The Washington County portion of the watershed also contains the largest amount of woodland-wetland areas not protected by public ownership—1,355 acres—with 1,315 acres, or 97 percent of that woodland-wetland area, being located within the primary environmental corridor. The greatest extent of wildlife habitat is also located in Washington County—3,544 acres—with 2,012 acres, or 57 percent, contained within the primary environmental corridor. Milwaukee County contains the largest amount of existing outdoor recreation sites—5,757 acres—with 3,381 acres, or 59 percent of that total, being within the limits of the primary environmental corridor.

Ownership and Land Use Controls: The distribution of primary environmental corridor lands in the watershed with respect to ownership and land use controls is shown on Map 3 and Figure 3. About 3,959 acres, or 38 percent, of the primary environmental corridor are in public ownership for outdoor recreation and related open space uses and another 682 acres, or about 7 percent of the corridor, is in private ownership for outdoor recreation and related open space uses. Therefore, a total of 4,641 acres of the primary environmental corridor is protected by virtue of either public or private ownership for outdoor recreation and related open space uses.

Of the remaining 5,798 acres of primary environmental corridor, 4,314 acres, or 41 percent of the total primary environmental corridor in the watershed, are partially protected by floodland, conservancy, and other zoning that places some restrictions on the use of the corridor lands. As shown on Map 3, such land use controls have been adopted and are administered by the Village of Germantown, the City of Mequon, the Village of Menomonee Falls, the City of Brookfield, the Village of Elm Grove, the City of Wauwatosa, and the City of Milwaukee.

The Village of Germantown has established a Conservancy District along the Menomonee River and its tributaries for the purpose of controlling use of or alteration to the natural resource base. Conditional uses that may be allowed in this district include agriculture and related activities, removal of topsoil and land filling, watercourse relocation, and recreational facilities.

The City of Mequon has created a Wetland and Floodplain District along the Little Menomonee River and its tributaries with the objective of controlling development so as to minimize health and safety hazards, to protect the natural resources, and to assure proper consideration of the general public welfare. A variety of compatible land uses such as harvesting of wild crops, hunting and fishing, and installation of telephone and power transmission lines is permitted by right of ownership. Conditional uses include farming and group outdoor recreational facilities. Buildings intended for human habitation are explicitly prohibited in the Wetland and Floodplain District whereas filling or draining of wetlands, removal of soil, the creation of ponds, and the altering of watercourses are allowed only with the approval of the City of Mequon Common Council upon recommendation of the Plan Commission.

The Village of Menomonee Falls has established the following three zoning districts that are pertinent to protection of the primary environmental corridors in the Menomonee River watershed portion of the village: a Park and Open Space District, a Conservancy-Wetlands District, and a Menomonee River Floodland District. The Park and Open Space District, which lies primarily along the Menomonee River and is generally coincident with existing public and private outdoor recreation and related open space lands, is intended to insure the continued use of such lands for recreational activities. To achieve this objective, a wide spectrum of outdoor recreation uses is allowed. Most of the land in the Conservancy-Wetlands District lies along the Menomonee River and Lilly Creek within the Village. The purpose of this District is to identify and retain riverine area lands in essentially natural conditions for their inherent ecologic, aesthetic, and recreational values rather than to permit urban development with the attendant environmental problems resulting from soil, topographic, and other natural resource base limitations. A large number of uses compatible with the natural conditions is allowed including fishing, hunting, wildlife preserves, stream bank protection, and soil and water conservation measures. Structures intended for human habitation are not permitted, and a permit is required for uses such as drainageway construction, grazing, farming, and installation of utilities. The third and last district—the Menomonee River Floodland District—applies only to that portion of theTamarack Swamp that lies within the watershed and is intended to achieve two objectives: protection of natural resources and prevention of flood

Table 9

NATURAL RESOURCE ELEMENTS IN THE MENOMONEE RIVER WATERSHED AND IN THE PRIMARY ENVIRONMENTAL CORRIDORS WITHIN THE WATERSHED BY CIVIL DIVISION: 1970

County or Civil Division	Natural Resource Elements													
					Woodlands and Wetlands[a]									
	Floodlands		Poor Soils		High Value		Medium Value		Moderate-Parkway		Moderate-Local		High Value	
	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)
Milwaukee County	2,245.82	1,743.57	2,447.17	1,175.33	--	--	--	--	15.35	--	12.87	--	--	--
Cities:														
Greenfield	142.61	40.96	167.86	46.08	--	--	--	--	--	--	--	--	--	--
Milwaukee	1,363.17	1,050.92	1,643.26	740.23	--	--	--	--	--	--	--	--	--	--
Wauwatosa	641.17	585.74	444.15	299.59	--	--	--	--	15.35	--	--	--	--	--
West Allis	98.87	65.95	191.90	89.43	--	--	--	--	--	--	12.87	--	--	--
Villages:														
Greendale	--	--	--	--	--	--	--	--	--	--	--	--	--	--
West Milwaukee	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ozaukee County	640.56	417.09	1,603.28	681.85	--	--	--	--	278.28	215.82	79.26	26.13	--	--
City:														
Mequon	640.56	417.09	1,603.28	681.85	--	--	--	--	278.28	215.82	79.26	26.13	--	--
Washington County	1,422.67	1,227.19	4,797.53	2,544.14	--	--	627.02	624.50	680.79	668.26	47.03	22.50	564.27	523.93
City:														
Milwaukee	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Village:														
Germantown	1,422.67	1,227.19	4,587.00	2,514.55	--	--	627.02	624.50	680.79	668.26	22.50	22.50	564.27	523.93
Towns:														
Germantown	--	--	59.41	24.71	--	--	--	--	--	--	--	--	--	--
Richfield	--	--	151.12	4.88	--	--	--	--	--	--	24.53	--	--	--
Waukesha County	924.88	678.30	4,450.37	2,134.65	83.64	83.64	396.31	391.27	173.06	145.35	354.42	329.00	411.31	396.24
Cities:														
Brookfield	205.54	178.05	2,269.69	1,213.43	83.64	83.64	--	--	--	--	334.10	308.68	--	--
New Berlin	--	--	42.86	--	--	--	--	--	--	--	--	--	--	--
Villages:														
Butler	69.53	69.53	22.50	4.94	--	--	12.61	7.57	17.51	17.51	--	--	--	--
Elm Grove	121.69	55.87	417.70	126.54	--	--	--	--	--	--	--	--	--	--
Menomonee Falls	528.12	374.85	1,623.81	769.42	--	--	383.70	383.70	155.55	127.84	--	--	411.31	396.24
Towns:														
Brookfield	--	--	51.00	20.32	--	--	--	--	--	--	20.32	20.32	--	--
Lisbon	--	--	22.81	--	--	--	--	--	--	--	--	--	--	--
Total	5,233.93	4,066.15	13,298.35	6,535.97	83.64	83.64	1,023.33	1,015.77	1,147.48	1 ,029.43	493.58	377.63	975.58	920.17

County or Civil Division	Natural Resource Elements											
	Wildlife Habitat						Existing Outdoor Recreation					
	Good Value		Moderate Value		Low Value		Public		Private			Percent of Total Primary Environmental Corridor In Watershed
	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Watershed (Acres)	In Corridor (Acres)	In Corridor[b] (Acres)	
Milwaukee County	251.22	224.44	1,433.90	1,182.79	--	--	5,112.77	3,078.33	653.84	302.47	3,728.93	35.72
Cities:												
Greenfield	--	--	--	--	--	--	99.41	51.20	60.52	--	76.80	0.74
Milwaukee	182.02	179.38	895.35	679.69	--	--	2,882.30	1,408.47	374.49	112.20	1,753.83	16.80
Wauwatosa	69.20	45.06	538.55	503.10	--	--	1,437.12	1,193.00	204.10	182.50	1,441.77	13.81
West Allis	--	--	--	--	--	--	667.13	425.66	14.73	7.77	456.53	4.37
Villages:												
Greendale	--	--	--	--	--	--	5.04	--	--	--	--	--
West Milwaukee	--	--	--	--	--	--	21.77	--	--	--	--	--
Ozaukee County	587.78	--	608.53	327.20	--	--	--	--	10.00	--	729.62	6.99
City:												
Mequon	587.78	--	608.53	327.20	--	--	--	--	10.00	--	729.62	6.99
Washington County	1,163.79	847.85	1,660.65	640.14	155.35	--	285.79	178.04	266.05	221.32	2,985.47	28.60
City:												
Milwaukee	--	--	--	--	--	--	--	--	10.00	--	--	--
Village:												
Germantown	1,069.66	818.20	1,582.13	615.62	155.35	--	275.83	178.04	226.61	194.35	2,928.85	28.06
Towns:												
Germantown	29.65	29.65	--	--	--	--	5.04	--	2.47	--	29.65	0.28
Richfield	64.48	--	78.52	24.52	--	--	4.92	--	26.97	26.97	26.97	0.26
Waukesha County	757.49	521.12	1,533.66	1,039.46	147.16	--	1,074.02	703.15	280.09	157.78	2,995.35	28.69
Cities:												
Brookfield	716.92	500.80	580.28	395.20	37.84	--	467.94	331.43	56.97	10.46	1,470.16	14.08
New Berlin	--	--	--	--	--	--	11.32	--	--	--	--	--
Villages:												
Butler	--	--	72.28	64.77	--	--	61.68	49.91	--	--	94.55	0.91
Elm Grove	20.25	--	37.83	35.26	--	--	128.53	120.91	30.51	--	159.27	1.53
Menomonee Falls	--	--	843.27	544.23	109.32	--	404.55	200.90	192.61	147.32	1,251.05	11.98
Towns:												
Brookfield	20.32	20.32	--	--	--	--	--	--	--	--	20.32	0.19
Lisbon	--	--	--	--	--	--	--	--	--	--	--	--
Total	2,760.28	1,593.41	5,236.74	3,189.59	302.51	--	6,472.58	3,959.52	1,209.98	681.57	10,439.37	100.00

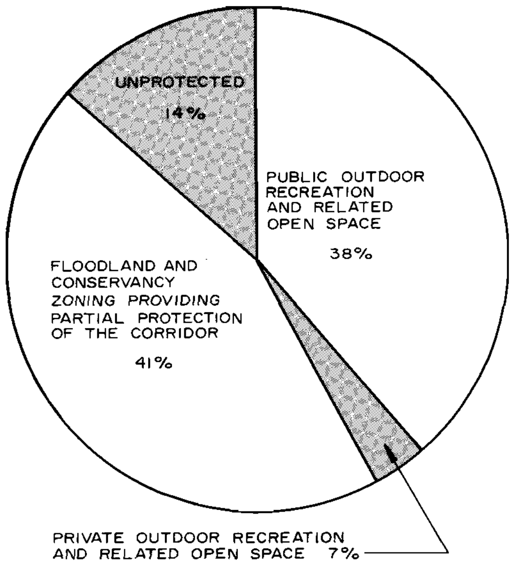
[a] *These woodlands and wetlands in the watershed are presently unprotected; the publicly and privately owned parks, outdoor recreation, and related open space sites that constrain woodlands were generally excluded from the woodland inventory.*

[b] *The total area of the corridor for each civil division does not equal the sum of the five natural resource elements since some Primary Environmental Corridor areas within a civil division contain two or more natural resource elements, and the acreage of the area was counted only once.*

Source: SEWRPC.

Figure 3

OWNERSHIP AND LAND USE CONTROLS IN THE PRIMARY ENVIRONMENTAL CORRIDOR OF THE MENOMONEE RIVER WATERSHED: 1975



NOTE:
1. THE CIRCLE REPRESENTS THE 16.31 SQUARE MILES OF PRIMARY ENVIRONMENTAL CORRIDOR IN THE WATERSHED.
2. FLOODLAND AND CONSERVANCY ZONING ARE INDICATED ONLY FOR THOSE CORRIDOR LANDS NOT IN THE PUBLIC OR PRIVATE OUTDOOR RECREATION AND RELATED OPEN SPACE CATEGORIES.

Source: SEWRPC.

problems. A full spectrum of uses compatible with the natural ecologic and topographic characteristics of the District is permitted by right of ownership including fishing, drainage, wildlife preserves, grazing, harvesting of wild crops, and recreation facilities. Conditional uses include bridges, utilities, excavation, and filling.

The City of Brookfield has established a Conservancy District, most of which is located along Butler Ditch, Underwood Creek, and Dousman Ditch in the Menomonee River watershed portion of the City. The purpose of this zoning is protection of the underlying natural resource base for the general welfare of the residents of Brookfield. Permitted uses by virtue of ownership include grazing, harvesting of wild crops, forestry, and certain nonresidential buildings. Top-soil removal, land filling, and watercourse damming or alteration all require permission of the City Plan Commission.

The Village of Elm Grove has created a Conservancy District in order to protect open space lands in the Village. Most of these areas are located along Underwood Creek Parkway Drive and Pilgrim Parkway Drive. Conditional uses that may be allowed in this District include ordinary farm use, grazing, harvesting of wild crops, and recreational facilities. However, neither residential nor nonresidential buildings of any sort may be constructed in this District.

The City of Wauwatosa has established a Floodplain District intended to achieve three objectives: prevent flood problems; minimize economic loss and hazards to life and general safety; and protect aesthetic and recreational values of the land. The floodway is reserved for parks, recreation and conservation open space, and no structures can be used or erected for human habitation. Residential, commercial, and industrial buildings may be constructed in the floodplain district; however, they are subject to restrictions pertaining to first floor elevations in order to make them flood-safe. Although this ordinance was adopted by the City prior to completion of the Menomonee River watershed planning program, it did not become effective until floodplain and floodway delineations were made available as a result of the planning program.

A Floodplain District exists along the Little Menomonee River in the City of Milwaukee. This is a limited purpose ordinance in that it is primarily intended to assure that buildings constructed within the District are properly elevated and placed on sufficient fill to protect them from flood damage. Although the provisions of this District render it ineffective for corridor preservation, this is not a serious problem since many of the lands in the District are also part of the Milwaukee County Park System and therefore protected by virtue of public ownership.

Table 10 summarizes salient features of the above land use controls that have been adopted by seven of the communities in the watershed and are applicable to primary environmental corridor lands. For each of the zoning districts, the table indicates the extent to which each of the following eight land uses and activities potentially destructive of primary environmental corridors are allowed: structures for human habitation; filling; removal of top-soil and/or excavation; watercourse alteration and/or damming; agriculture; group recreational facilities; drainage of wetlands; and placement of public utilities. The table was developed by using explicit references to each of the eight land uses or activities in the zoning regulations supplemented with interpretations of the stated intent of the regulations.

All of the districts in all of the zoning regulations, with the exception of the Floodplain District in the City of Milwaukee, either require a conditional permit or expressly prohibit all eight land uses or activities. Therefore, the Village of Germantown, the City of Mequon, the Village of Menomonee Falls and the City of Brookfield, the Village of Elm Grove, and the City of Wauwatosa already have land use controls that could be applied to protect the portions of the unprotected primary environmental corridor within their community boundaries. This is a very significant finding with respect to the corridor protection element of the Menomonee River watershed plan in that about 74 percent of the approximately 5,800 acres of primary environmental corridor not protected by virtue of being public or private outdoor recreation and related open space lands are subject to control by the above zoning regulations.

Unit Cost of Corridor Lands: Existing land values in primarily unimproved riverine areas of the watershed were examined to provide a basis for estimating the cost of alternative plan elements for corridor protection involving land acquisition.[5] This examination was concentrated in the Ozaukee, Washington, and Waukesha Counties portions of the watershed inasmuch as most of the unimproved riverine area land with potential for public acquisition is located in the rural portions of these three counties. Sample parcels of primary environmental corridor lands were selected, and civil division assessors and other public officials were contacted on a community by community basis to obtain estimates of the market value of the sample parcels. The range of unit values for land in the various portions of the watershed was analyzed, and a representative unit value selected for each portion of the watershed was set forth in Table 11. Riverine area land values were found to vary from about $250 per acre for unimproved wetland in the most rural portions of the watershed to more than $20,000 per acre for improved land provided with public utility service in the highly urbanized lower portions of the watershed. It is important to emphasize that the land values set forth in Table 11 are meant to be representative of average values over relatively large subareas of the watershed and that actual land values in any specific location in the watershed may be expected to vary from the representative average value appearing in the table. The primary purpose of assigning unit land values was to provide a means of comparing in an internally consistent manner the estimated cost of the alternative primary environmental corridor plan elements described later in this chapter. It should also

[5] *Unit cost of riverine area lands also was used as input to the Flood Economics Submodel described in Chapter VIII, Volume 1, of this report.*

Table 10

SUMMARY OF EXISTING LAND USE CONTROLS HAVING THE POTENTIAL TO PROTECT THE PRIMARY ENVIRONMENTAL CORRIDORS IN THE MENOMONEE RIVER WATERSHED: 1975

		Selected Land Uses or Activities and the Extent to Which They Are Allowed in the District											
		Structures for Human Habitation			Filling			Removal of Top-soil and/or Excavation			Watercourse Alteration and/or Damming		
Civil Division	District Name	Permitted by Virtue of Ownership	Conditional Use	Prohibited	Permitted by Virtue of Ownership	Conditional Use	Prohibited	Permitted by Virtue of Ownership	Conditional Use	Prohibited	Permitted by Virtue of Ownership	Conditional Use	Prohibited
Village of Germantown	Conservancy		X			X			X			X	
City of Mequon	Wetland and Floodplain			X		X			X			X	
Village of Menomonee Falls	Park and Open Space		X			X			X			X	
	Conservancy-Wetland			X			X			X			X
	Floodland					X			X			X	
City of Brookfield	Conservancy		X			X			X			X	
Village of Elm Grove	Conservancy			X		X			X			X	
City of Milwaukee	Floodplain		X			X		N/A	N/A	N/A		N/A	
City of Wauwatosa	Floodway			X		X				X		X	
	Floodplain		X		X			X				X	

		Selected Land Uses or Activities and the Extent to Which They Are Allowed in the District											
		Agriculture and Related			Recreational Facilities			Draining of Wetlands			Utilities		
Civil Division	District Name	Permitted by Virtue of Ownership	Conditional Use	Prohibited	Permitted by Virtue of Ownership	Conditional Use	Prohibited	Permitted by Virtue of Ownership	Conditional Use	Prohibited	Permitted by Virtue of Ownership	Conditional Use	Prohibited
Village of Germantown	Conservancy		X			X			X			X	
City of Mequon	Wetland and Floodplain		X			X			X			X	
Village of Menomonee Falls	Park and Open Space		X			X			X			X	
	Conservancy-Wetland		X			X			X			X	
	Floodland		X			X		X				X	
City of Brookfield	Conservancy		X			X			X			X	
Village of Elm Grove	Conservancy		X			X			X			X	
City of Milwaukee	Floodplain		N/A			N/A			N/A			N/A	
City of Wauwatosa	Floodway		X			X			X			X	
	Floodplain	X				X			X			X	

NOTE: N/A indicates data not applicable.

Source: SEWRPC.

be emphasized that the unit land values reflect 1975 conditions, and the values of individual sites may change markedly in the future in response to changing local conditions such as provision of public utility service.

Concluding Statement: Any plan for the preservation, protection, and wise use of the natural resource base within the watershed must be centered on the preservation and protection of the remaining primary environmental corridor. One of the principal objectives of the adopted regional land use plan, upon which the Menomonee River watershed is based, is the preservation of the primary environmental corridors from further degradation. Recent trends within Southeastern Wisconsin in general, and the Menomonee River watershed in particular, have resulted in the encroachment of urban development into the corridor. Currently, the Menomonee River watershed contains only remnants of important

Table 11

REPRESENTATIVE RIVERINE AREA LAND COSTS IN THE MENOMONEE RIVER WATERSHED: 1975

Identification of Area[a]		Land Value[b] Dollars/Acre
Stream or Other Location	Reach	
North Branch of Menomonee River	Entire length	300
Willow Creek	Entire length	300
Upper Menomonee River	Upstream (north) of Waukesha-Washington County line (CTH Q)	300
	Downstream (south) of Waukesha-Washington County line (CTH Q) and upstream (north) of Good Hope Road (CTH PP)	600
	Downstream (south) of Mill Road and upstream (north) of Silver Spring Drive (CTH VV)	5,000
Nor-X-Way Channel	Upstream (north) of Donges Bay Road	300
Lilly Creek	Upstream (south) of Silver Spring Drive (CTH VV)	5,000
Butler Ditch	Entire length	5,000
Little Menomonee River	Upstream (north) of Ozaukee-Milwaukee County line (CTH Q)	300
	Downstream (south) of Ozaukee-Milwaukee County line (CTH Q) and upstream (north) of Bradley Road	5,000
	Downstream (south) of Silver Spring Drive (CTH E)	20,000
Lower Menomonee River	Upstream (west) of the Stadium Freeway	20,000
Dousman Ditch	Upstream (west) of Calhoun Road (CTH KX)	1,000
	Downstream (east) of Calhoun Road (CTH KX)	3,500
Underwood Creek	Upstream (west) of Pilgrim Road	3,500
	Downstream (east) of Pilgrim Road (CTH YY) and upstream (north) of Juneau Boulevard	5,000
South Branch of Underwood Creek	Downstream (north) of IH 94	5,000
Honey Creek	Upstream (south) of IH 894	5,000
Tamarack Swamp	- -	250
Bishops Woods	- -	35,000
Wooded area in Section 24, T9N, R20E	- -	5,000

[a] *Limited to primary environmental corridor lands located primarily in riverine areas and for which public acquisition was considered under Primary Environmental Corridor Subelements 2 or 3.*

[b] *The wide range in land values reflects the use of adjacent and nearby lands and the availability of water supply service, sanitary sewerage, streets and highways, and other urban services and facilities.*

Source: Civil Division Assessors and Other Officials and SEWRPC.

natural resource elements such as streams, woodlands, wetlands, and wildlife habitat and most of the elements that do remain are generally of lower quality. However, these remaining remnants have the potential to contribute substantively to the stability of the ecosystem and the quality of life in the Menomonee River watershed.

Three alternative natural resource protection subelements were developed and examined to provide for the preservation, protection, and wise use of these best remaining elements of the natural resource base, with emphasis on protecting and preserving the regenerative qualities of that base, including soils, surface and ground water, wetlands, woodlands, and wildlife. The salient features of each of the three alternatives are set forth in Table 12 and each of the alternative natural resource protection subelements is described in detail in the following sections of this chapter.

Primary Environmental Corridor
Subelement 1: Minimum Protection
The first alternative primary environmental corridor subelement considered was a minimum design consisting of maintaining the use of existing public and private outdoor recreation and related open space lands and of using existing and new land use controls to protect the remaining corridor lands. In addition, sound woodland, wetland, and wildlife management practices would be instituted for all corridor lands in the watershed. Map 3 graphically illustrates the basic features of this alternative while the implications of this subelement for each civil division in the watershed are summarized in Table 13. Each of the three components incorporated in the minimum protection primary environmental corridor subelement is discussed below.

Maintenance of Existing Outdoor Recreation and Related Open Space: This component recognizes that existing public and private outdoor recreation and related open

Table 12

ALTERNATIVE PRIMARY ENVIRONMENTAL CORRIDOR PROTECTION SUBELEMENTS FOR THE MENOMONEE RIVER WATERSHED

Subelement	Component	Area		Acquisition Cost (in Dollars)
		Acres	Percent of Primary Environmental Corridor	
1. Minimum Protection	a. Maintenance of existing public and private outdoor recreation and related open space lands in the primary environmental corridor.	4,641	44.46	- -
	b. Use of land use controls to protect remaining primary environmental corridor.	5,798	55.54	- -
	c. Application of woodland, wetland, and wildlife habitat management techniques to all corridor lands.	10,439	100.00	- -
2. Intermediate Protection	a. Maintenance of existing public and private outdoor recreation and related open space lands in the primary environmental corridor.	4,641	44.46	- -
	b. Acquisition of selected high value primary environmental corridor lands along the main stem of the Menomonee River and at five other locations in the watershed.	3,062	29.33	2,183,050
	c. Use of land use controls to protect remaining primary environmental corridor.	2,736	26.21	- -
	d. Application of woodland, wetland, and wildlife habitat management techniques to all corridor lands.	10,439	100.00	- -
3. Maximum Protection	a. Maintenance of existing public and private outdoor recreation and related open space lands in the primary environmental corridor.	4,641	44.46	- -
	b. Acquisition of all remaining primary environmental corridor lands.	5,798	55.54	14,749,150
	c. Application of woodland, wetland, and wildlife habitat management techniques to all corridor lands.	10,439	100.00	- -

Source: SEWRPC.

space lands comprise a significant part of the primary environmental corridor and in effect help to protect the corridor. These lands total 4,641 acres, or about 45 percent of the total primary environmental corridor in the watershed and approximately 5 percent of the watershed area.

Use of Land Use Controls: This component involves protection of the remaining primary environmental corridor in the watershed through intensified application of existing and additional land use controls intended to maintain the corridor lands in essentially natural open space uses. This can be achieved largely through the use of agricultural, floodland, shoreland conservancy, and very low-density residential zoning within the watershed. This zoning should, at a minimum, encompass all of the riverine areas of the watershed lying within the primary environmental corridor. Such zoning will help protect the remaining woodlands, wetlands, and wildlife habitat areas, as well as the floodlands and water within the watershed from continued deterioration and destruction by fragmented urban development. These zoning measures will also serve to prevent intensification of flood problems within the watershed.

With the passage of the State Water Resources Act in 1966, the Wisconsin Legislature recognized the need for floodway and floodplain fringe regulation. Under this Act, the Wisconsin Department of Natural Resources is authorized to enact floodland zoning regulations when it finds that a county, city, or village has not adopted reasonable and effective regulations. These floodland regulations take the form of or are incorporated into zoning, subdivision, sanitary, and building ordinances used to restrict an owner in the use of his property when such use is harmful to the public. Therefore, the eventual adoption of these regulations for watershed floodlands, as those floodlands have been delineated under the watershed planning program, will contribute to the protection of the floodland portion of the primary environmental corridors.

The areas intended for protection by various land use controls total 5,798 acres, or about 55 percent of the total primary environmental corridor in the watershed and approximately 7 percent of the watershed area. About 74 percent of the above area proposed for protection by various land use controls is already subject to some form of land use controls consistent with protection of the primary environmental corridor.

Management of Woodlands, Wetlands and Wildlife Habitat: This component involves the application of sound management techniques to all woodland, wetland, and wildlife habitat areas in general in the watershed and, in particular, to those located within the primary environ-

Table 13

PRIMARY ENVIRONMENTAL CORRIDOR SUBELEMENT 1: MINIMUM PROTECTION

	Primary Environmental Corridor			Primary Environmental Corridor Presently Protected by Public or Private Outdoor Recreational and Related Open Space Use			Primary Environmental Corridor to be Protected Primarily by Existing Land Use Controls			Primary Environmental Corridor to be Protected by New Land Use Controls		
Civil Division	Acres	Percent of Watershed Total	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total
Milwaukee County												
Cities:												
Greenfield	76.80	0.74	3.77	51.20	66.67	2.52	--	--	--	25.60	33.33	1.25
Milwaukee	1,753.83	16.80	8.82	1,520.67	86.71	7.65	190.03	10.84	0.96	43.13	2.45	0.21
Wauwatosa	1,441.77	13.81	17.03	1,375.50	95.40	16.25	--	--	--	66.27	4.60	0.78
West Allis	456.53	4.37	8.98	433.43	94.94	8.53	--	--	--	23.10	5.06	0.45
Villages:												
Greendale	--	--	--	--	--	--	--	--	--	--	--	--
West Milwaukee	--	--	--	--	---	--	--	--	--	--	--	--
Ozaukee County												
City:												
Mequon	729.62	6.99	9.60	--	--	--	661.67	90.69	8.70	67.95	9.31	0.90
Washington County												
City:												
Milwaukee	--	--	--	--	--	--	--	--	--	--	--	--
Village:												
Germantown	2,928.85	28.06	15.71	372.39	12.71	2.0	2,115.98	72.25	11.35	440.48	15.04	2.36
Towns:												
Germantown	29.65	0.28	5.65	--	--	--	--	--	--	29.65	100.00	5.65
Richfield	26.97	0.26	2.24	26.97	100.00	2.24	--	--	--	--	--	--
Waukesha County												
Cities:												
Brookfield	1,470.16	14.08	17.05	341.89	23.26	3.97	591.08	40.21	6.85	537.19	36.53	6.23
New Berlin	--	--	--	--	--	--	--	--	--	--	--	--
Villages:												
Butler	94.55	0.91	18.94	49.91	52.79	10.00	--	--	--	44.64	47.21	8.94
Elm Grove	159.27	1.53	7.66	120.91	75.92	5.81	10.28	6.45	0.50	28.08	17.63	1.35
Menomonee Falls	1,251.05	11.98	10.48	348.22	27.83	2.92	724.64	57.92	6.07	178.19	14.25	1.49
Towns:												
Brookfield	20.32	0.19	13.23	--	--	--	20.32	100.00	13.23	--	--	--
Lisbon	--	--	--	--	--	--	--	--	--	--	--	--
Total	10,439.37	100.00	--	4,641.09	--	--	4,314.00	--	--	1,484.28	--	--

NOTE: In addition to the above components, subelement 1 includes application of woodland, wetland, and wildlife habitat management techniques to all corridor lands.

Source: SEWRPC.

mental corridor. In order for wildlife habitat areas to retain their qualities, specific management practices should be established, such as limiting the use of fertilizers and pesticides, reducing road salting, and in specific wildlife areas reducing heavy vehicular traffic that produces disruptive noise levels along with potentially damaging air pollution. Land clearing for agricultural or urban development purposes—including logging, ditching and tilling—have either removed the natural vegetation from much of the watershed or have greatly altered the woodland-wetland areas. By exercising control over such activities and by applying good management practices in general to woodland-wetlands and wildlife habitats, their protection and wise use can be ensured outside and inside the primary environmental corridor.

This component applies to the 2,506 acres of woodland-wetland area and the 5,703 acres of wildlife habitat within the primary environmental corridors of the watershed as well as to an additional 242 acres of woodland-wetland and 3,572 acres of wildlife habitat located in the basin but outside the primary environmental corridors.

Primary Environmental Corridor
Subelement 2: Intermediate Protection

The second alternative primary environmental corridor subelement considered was an intermediate design that would maintain the use of existing public and private outdoor recreation and related open space lands plus involve the public acquisition of selective lands to protect remaining high value portions of the primary environmental corridor. In addition, sound woodland, wetland, and wildlife management practices would be instituted for all corridor lands in the watershed. Map 4 and Table 14 summarize the features of this subelement for the watershed and each civil division. Each of the three components incorporated in the intermediate protection primary environmental corridor subelement is discussed below.

Maintenance of Existing Outdoor Recreation and Related Open Space: This component, which is common with the minimum protection subelement, recognizes that existing public and private outdoor recreation and related open space lands comprise a significant part of the primary environmental corridor and in effect help to protect the corridor. Public and private outdoor

Table 14

PRIMARY ENVIRONMENTAL CORRIDOR SUBELEMENT 2: INTERMEDIATE PROTECTION

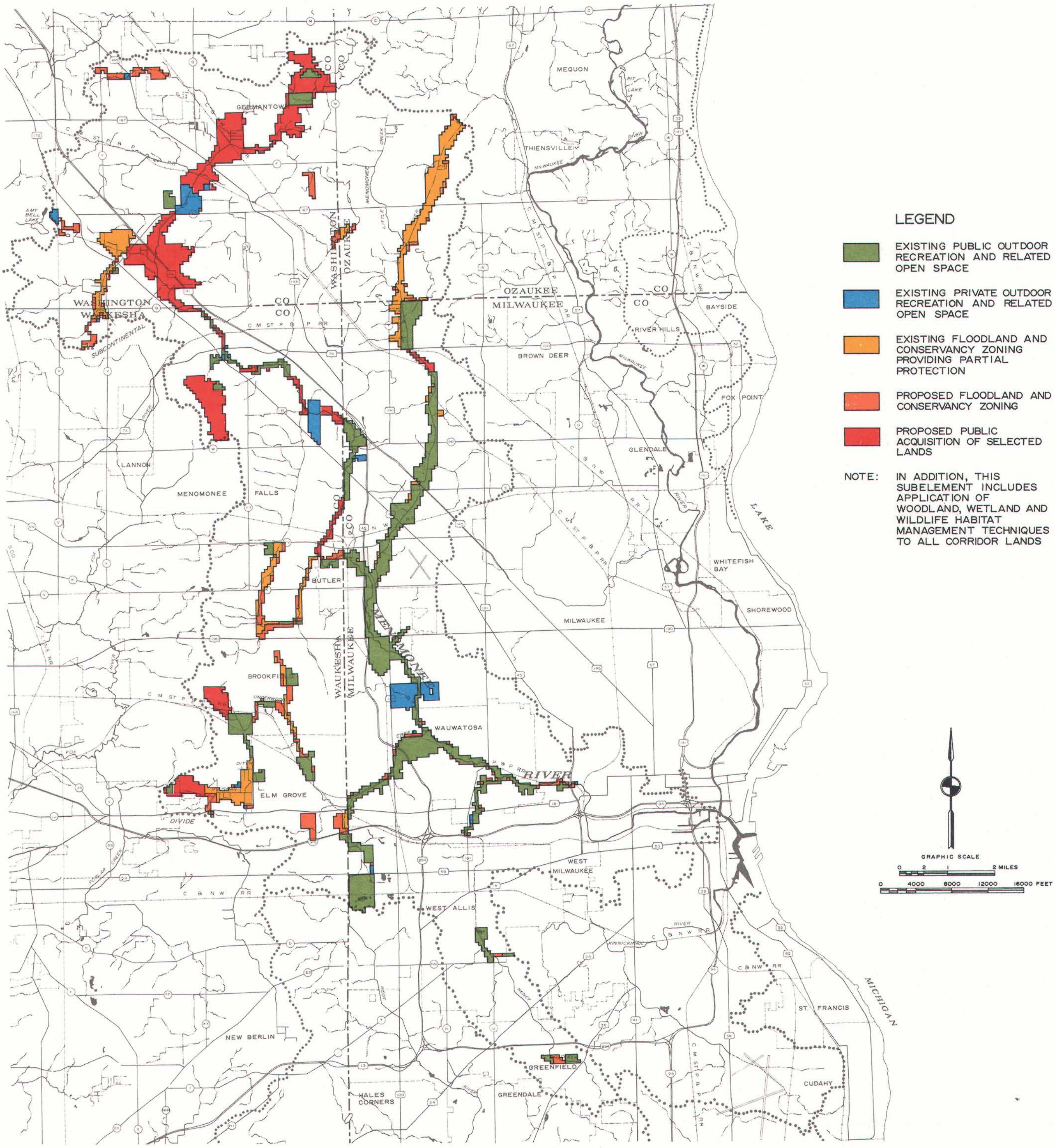
Civil Division	Primary Environmental Corridor			Primary Environmental Corridor Presently Protected by Public or Private Outdoor Recreational and Related Open Space Use			Primary Environmental Corridor Protected by Selective Public Acquisition				Primary Environmental Corridor to be Protected Primarily by Existing Land Use Controls			Primary Environmental Corridor to be Protected by New Land Use Controls		
	Acres	Percent of Watershed Total	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total	Cost (in Dollars)	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total
Milwaukee County																
Cities:																
Greenfield	76.80	0.74	3.77	51.20	66.67	2.52	--	--	--	--	--	--	--	25.60	33.33	1.25
Milwaukee	1,753.83	16.80	8.82	1,520.67	86.71	7.65	48.43	2.76	0.24	242,150.00	141.60	8.07	0.71	43.13	2.46	0.22
Wauwatosa	1,441.77	13.81	17.03	1,375.50	95.40	16.25	--	--	--	--	--	--	--	66.27	4.60	0.78
West Allis	456.53	4.37	8.98	433.43	94.94	8.53	--	--	--	--	--	--	--	23.10	5.06	0.45
Villages:																
Greendale	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
West Milwaukee	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Ozaukee County																
City:																
Mequon	729.62	6.99	9.60	--	--	--	--	--	--	--	661.67	90.69	8.70	67.95	9.31	0.90
Washington County																
City:																
Milwaukee	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Village:																
Germantown	2,928.85	28.06	15.71	372.39	12.71	2.0	2,035.69	69.50	10.92	615,250.00	279.80	9.55	1.50	240.97	8.24	1.29
Towns:																
Germantown	29.65	0.28	5.65	--	--	--	--	--	--	--	--	--	--	29.65	100.00	5.65
Richfield	26.97	0.26	2.24	26.97	100.00	2.24	--	--	--	--	--	--	--	--	--	--
Waukesha County																
Cities:																
Brookfield	1,470.16	14.08	17.05	341.89	23.26	3.97	282.94	19.25	3.28	654,200.00	432.71	29.43	5.02	412.62	28.06	4.78
New Berlin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Villages:																
Butler	94.55	0.91	18.94	49.91	52.79	10.00	14.96	15.82	3.00	74,800.00	--	--	--	29.68	31.39	5.94
Elm Grove	159.27	1.53	7.66	120.91	75.92	5.81	--	--	--	--	10.28	6.45	0.50	28.08	17.63	1.35
Menomonee Falls	1,251.05	11.98	10.48	348.22	27.83	2.92	659.81	52.74	5.52	576,350.00	168.19	13.45	1.41	74.83	5.98	0.63
Towns:																
Brookfield	20.32	0.19	13.23	--	--	--	20.32	100.00	13.23	20,300.00	--	--	--	--	--	--
Lisbon	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Total	10,439.37	100.00	--	4,641.09	--	--	3,062.15	--	--	2,183,050.00	1,694.25	--	--	1,041.88	--	--

NOTE: In addition to the above components, subelement 2 includes application of woodland, wetland, and wildlife management techniques to all corridor lands.

Source: SEWRPC.

Map 4

PRIMARY ENVIRONMENTAL CORRIDOR SUBELEMENT 2: INTERMEDIATE PROTECTION



The intermediate alternative plan for protection of the primary environmental corridors of the watershed includes three basic recommendations: maintaining the present use of the existing public and private outdoor recreation and related open space lands in the corridors; public acquisition of selected high value portions of the corridors; and application of sound woodland, wetland, and wildlife management practices to all corridor lands. Under this alternative, the 45 percent of the primary environmental corridor in the watershed currently in public and private outdoor recreation and related open space uses would continue to be maintained in those uses, and about 29 percent of the primary environmental corridors, most of them located along the main stem of the Menomonee River in Washington and Waukesha Counties, would be acquired at an estimated cost of $2.2 million for public outdoor recreation and related uses. This intermediate protection alternative was selected for inclusion in the recommended comprehensive plan for the Menomonee River watershed.

Source: SEWRPC.

recreation and related open space lands total 4,641 acres, or about 45 percent of the total primary environmental corridor in the watershed and approximately 5 percent of the watershed area.

Acquisition of Selected Remaining High Value Corridor Lands: This component involves the purchase of selected high value primary environmental corridors from private landowners using public funds—the most effective means whereby environmental corridors can be reserved for public use. The principal advantages of this approach are its definitiveness and legal incontestability whereas the key disadvantage is the cost.

An example of the feasibility and effectiveness of purchasing environmental corridors is provided by the park system of Milwaukee County—the most populated of the seven counties in southeastern Wisconsin. The Milwaukee County Park System, which is composed of most of the parks in the County including those within the various cities and villages in the County, was developed over an approximately 70-year period and currently encompasses 9 percent of the land area of the County. A large proportion of the Milwaukee County park land is in the form of continuous linear bands generally coincident with the floodlands and associated environmental corridors of the various streams flowing within the county. This park system provides a large-scale example of the environmental corridor idea implemented over a long period of time in a major metropolitan area.

Primary environmental corridor lands having the highest value, and not included in existing public and private outdoor recreation and related open space lands, were identified by examining the results of the analyses performed with the Land DMS supplemented by other pertinent information such as the location of potential outdoor recreation and related open space sites. The resulting high value primary environmental corridor lands total 3,062 acres, or about 29 percent of the primary environmental corridor in the watershed and approximately 3 percent of the watershed area. As shown on Map 4, most of this high value corridor—2,319 acres, or about 76 percent of it—is located in several continuous segments along the main stem of the Menomonee River in Washington and Waukesha Counties. The remaining four portions of the high value corridor lands that would be acquired under this subelement are distributed about the watershed as follows: a 48-acre linear portion bounded at both ends by Milwaukee County Park System lands along the Little Menomonee River in the City of Milwaukee, a 395-acre portion of the Tamarack Swamp in the Village of Menomonee Falls, and two portions of the Brookfield Swamp in the City and Town of Brookfield having a combined area of 303 acres.

The cost of acquiring the above high value primary environmental corridor is estimated at $2,183,050 for an average of about $713 per acre. As indicated in Table 14, $1,325,650, or about 61 percent of the total acquisition cost, would be expended in the Waukesha County portion of the watershed; $615,250, or about 28 percent in the Washington County portion; none in the Ozaukee County portion; and $242,150, or about 11 percent, in the Milwaukee County portion. Under this primary environmental corridor plan subelement, land acquisitions would occur in 6 of the 18 cities, villages, and towns located wholly or partly in the watershed. The largest expenditure—$654,200—would occur in the City of Brookfield and the smallest—$20,300—would occur in the Town of Brookfield.

Application of Land Use Controls: This component proposes that primary environmental corridor lands not in public or private park and related open space use and not slated for acquisition be protected through intensified application of existing and additional land use controls intended to maintain the corridor lands in essentially natural open space uses. This intent can be achieved largely through the use of agricultural, floodland, shoreland conservancy, and very low-density residential zoning within the watershed. At a minimum, this zoning should encompass all of the riverine areas of the watershed lying within the primary environmental corridor.

The areas intended for protection by various land use controls total 2,736 acres, or about 26 percent of the total primary environmental corridor in the watershed and approximately 3 percent of the watershed area. About 62 percent of the above area proposed for protection by various land use controls is already subject to some form of land use controls consistent with protection of the primary environmental corridor.

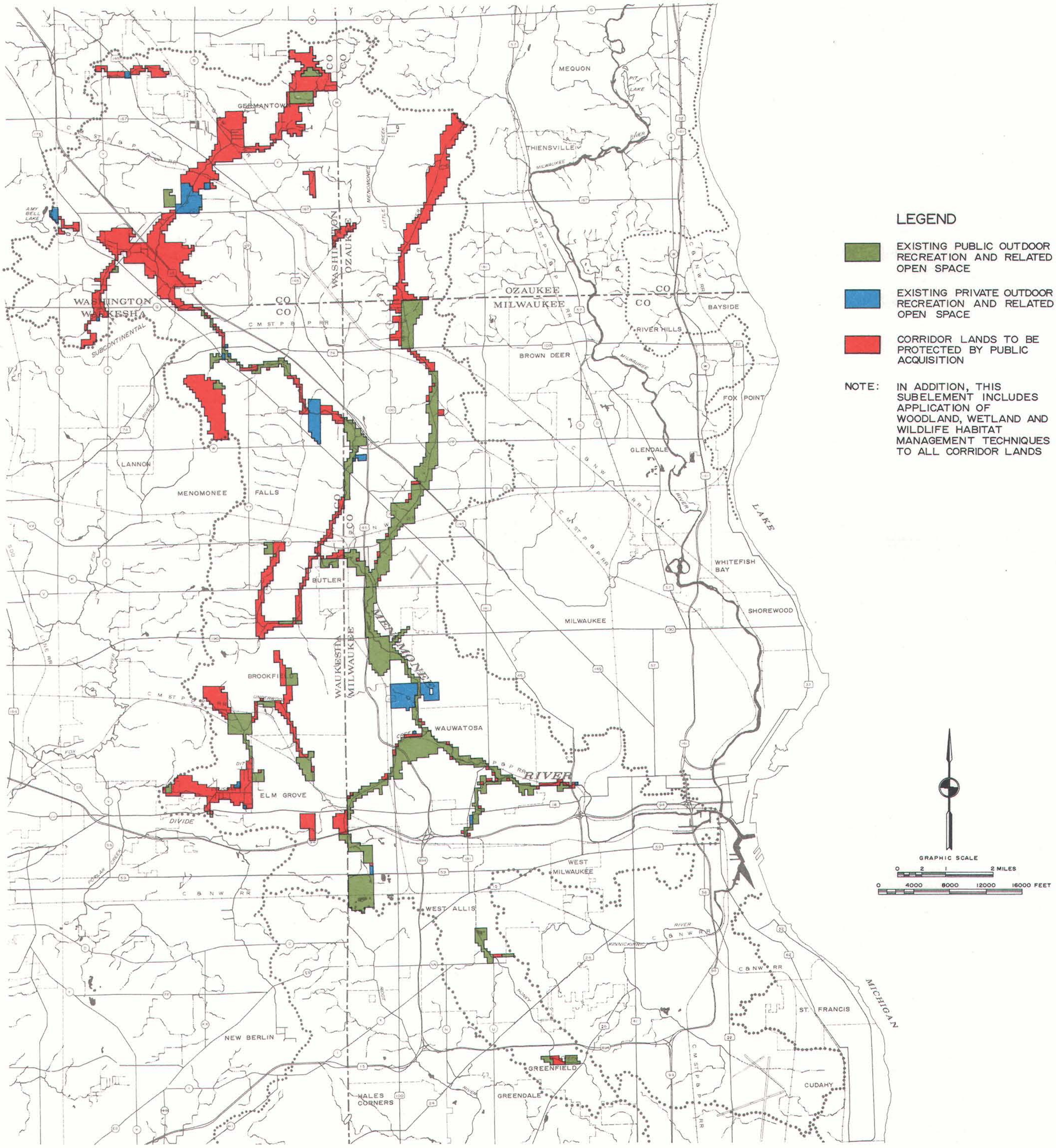
Management of Woodlands, Wetlands and Wildlife Habitat: This component, which is identical to that incorporated in the minimum primary environmental corridor subelement, involves the application of sound management techniques to all woodland, wetland, and wildlife habitat areas in the watershed. These management techniques would be applied to the 2,506 acres of woodland-wetland area and 5,703 acres of wildlife habitat within the primary environmental corridors of the watershed as well as to an additional 242 acres of woodland-wetland and 3,572 acres of wildlife habitat located in the basin but outside of the primary environmental corridors.

Primary Environmental Corridor
Subelement 3: Maximum Protection

The third alternative primary environmental corridor subelement considered was a maximum design consisting of maintaining the use of existing public and private outdoor recreation and related open space lands and of using public land acquisition to protect all of the remaining corridor area. In addition, sound woodland, wetland and wildlife management practices would be instituted for all corridor lands in the watershed. Map 5 and Table 15 summarize the features of this subelement for the watershed and each civil division. Each of the three components incorporated in the maximum protection primary environmental corridor subelement is discussed below.

Map 5

PRIMARY ENVIRONMENTAL CORRIDOR SUBELEMENT 3: MAXIMUM PROTECTION



The maximum alternative plan for protection of the primary environmental corridors of the watershed includes three basic recommendations: maintaining the present use of the existing public and private outdoor recreation and related open space lands in the corridors; public acquisition of all other corridor areas; and application of sound woodlands, wetland, and wildlife management practices to all corridor lands. Under this alternative, the 45 percent of the total primary environmental corridor in the watershed currently in public and private use would be maintained in that use and the remaining 55 percent of the primary environmental corridor lands would be purchased for public use at an estimated cost of $14.7 million.

Source: SEWRPC.

Maintenance of Existing Outdoor Recreation and Related Open Space: This component, which appears also in the first and second corridor protection subelements, recognizes that existing public and private outdoor recreation and related open space lands comprise a significant part of the primary environmental corridor and, in effect, help to protect the corridor. These public and private lands total 4,641 acres, or about 45 percent of the total primary environmental corridor in the water and about 5 percent of the watershed area.

Acquisition of Remaining Corridor Lands: This component relies on the outright purchase of primary environmental corridors from private land owners using public funds. The areas to be acquired under this subelement total 5,798 acres, or about 55 percent of the primary environmental corridor in the watershed and about 7 percent of the watershed area. The cost of this acquisition is estimated at $14,749,150 for an average of about $2,544 per acre. As indicated in Table 15, $10,070,200, or about 68 percent of the total acquisition cost, would be expended in the Waukesha County portion; $1,004,600, or about 7 percent, in the Washington County portion; $218,900, or about 2 percent in the Ozaukee County portion, and $3,455,450, or about 23 percent, in the Milwaukee County portion. Under this primary environmental corridor subelement, land acquisitions would occur in 12 of the 18 cities, villages, and towns located wholly or partly in the watershed with the largest expenditure—$8,265,900—occurring in the City of Brookfield and the smallest—$8,900—occurring in the Town of Germantown.

Management of Woodlands, Wetlands, and Wildlife Habitat: This component, which is identical to that incorporated in the minimum and intermediate primary environmental corridor subelements, involves the application of sound management techniques to all woodland, wetland, and wildlife habitat areas in the watershed. These management techniques would be applied to the 2,506 acres of woodland-wetland area and 5,703 acres of wildlife habitat within the primary environmental corridors of the watershed as well as to an additional 242 acres of woodland-wetland and 3,572 acres of wildlife habitat located in the basin but outside of the primary environmental corridors.

Table 15

PRIMARY ENVIRONMENTAL CORRIDOR SUBELEMENT 3: MAXIMUM PROTECTION

Civil Division	Primary Environmental Corridor			Primary Environmental Corridor Presently Protected by Public or Private Outdoor Recreational and Related Open Space Use			Primary Environmental Corridor to be Protected by Public Acquisition			
	Acres	Percent of Watershed Total	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total	Acres	Percent of Total Primary Environmental Corridor in Civil Division	Percent of Civil Division Total	Cost (in Dollars)
Milwaukee County										
Cities:										
Greenfield	76.80	0.74	3.77	51.20	66.67	2.52	25.60	33.33	1.25	128,000.00
Milwaukee	1,753.83	16.80	8.82	1,520.67	86.71	7.65	233.16	13.29	1.17	1,960,950.00
Wauwatosa	1,441.77	13.81	17.03	1,375.50	95.40	16.25	66.27	4.60	0.79	1,251,000.00
West Allis	1,456.53	4.37	8.98	433.43	94.94	8.53	23.10	5.06	0.45	115,500.00
Villages:										
Greendale	--	--	--	--	--	--	--	--	--	--
West Milwaukee	--	--	--	--	--	--	--	--	--	--
Ozaukee County										
City:										
Mequon	729.62	6.99	9.60	--	--	--	729.62	100.00	9.60	218,900.00
Washington County										
City:										
Milwaukee	--	--	--	--	--	--	--	--	--	--
Villages:										
Germantown	2,928.85	28.06	15.71	372.39	12.71	2.0	2,556.46	87.29	13.71	995,700.00
Towns:										
Germantown	29.65	0.28	5.65	--	--	--	29.65	100.00	--	8,900.00
Richfield	26.97	0.26	2.24	26.97	100.00	2.24	--	--	--	--
Waukesha County										
Cities:										
Brookfield	1,470.16	14.08	17.05	341.89	23.26	3.97	1,128.27	76.74	13.08	8,265,900.00
New Berlin	--	--	--	--	--	--	--	--	--	--
Villages:										
Butler	94.55	0.91	18.94	49.91	52.79	10.00	44.64	47.21	8.94	223,200.00
Elm Grove	159.27	1.53	7.66	120.91	75.92	5.81	38.36	24.08	1.85	188,000.00
Menomonee Falls	1,251.05	11.98	10.48	348.22	27.83	2.92	902.83	72.17	7.56	1,372,800.00
Towns:										
Brookfield	20.32	0.19	13.23	--	--	--	20.32	100.00	13.23	20,300.00
Lisbon	--	--	--	--	--	--	--	--	--	--
Total	10,439.37	100.00	--	4,641.09	--	--	5,798.28	--	--	14,749,150.00

NOTE: In addition to the above components, subelement 1 includes application of woodland, wetland, and wildlife habitat management techniques to all corridor lands.

Source: SEWRPC.

Concluding Remarks: Alternative Primary Environmental Corridor Protection Subelements

The relative effectiveness of the three alternative primary environmental corridor protection subelements in meeting the watershed development objectives and standards relating to floodlands, woodlands, wetlands, and wildlife habitat and in meeting outdoor recreational needs is summarized in Table 16. All three alternatives have the potential to perform well with respect to these standards and needs. The second or intermediate protection alternative would better meet the specified needs than the first or minimum protection alternative since the latter does not include public acquisition of woodlands, wetlands, and wildlife habitat, while the former incorporates public acquisition of 3,062 acres of high value corridor lands, thus providing greater assurance of permanent protection and preservation of a larger amount of such area. Similarly, the third alternative subelement would better meet the watershed natural resource-related objectives than either the first or second alternative because, again, there would be greater public acquisition of primary environmental corridor lands—a total of 5,798 acres would be acquired under this alternative. The ability of each of the three subelements to meet each of the six standards or needs identified in Table 16 is discussed below.

Floodlands: Standards supporting the adopted water control facility objectives specify maintenance in an essentially natural open space condition of all 100-year recurrence interval floodlands that are unoccupied by or not yet committed to urban development. Inasmuch as about 78 percent of the watershed floodlands are contained within the primary environmental corridors, corridor subelement 3 would significantly contribute to meeting this standard through public acquisition of all corridor lands not presently in public or private outdoor recreational and related open space use with floodland regulations being applied to noncorridor floodlands. Subelements 1 and 2 could achieve the desired floodland protection through adoption of floodland regulations for unprotected floodlands that meet the minimum requirements of the State of Wisconsin floodland management program while incorporating a comprehensive approach to floodland management.

Woodlands: The adopted land use planning objectives are supported by a standard requiring the preservation of 10 percent—13.7 square miles—of the Menomonee River watershed land area in woodland. As discussed in detail in Chapter IX of Volume 1 of this report, the total existing woodlands in the watershed, including those on public and private outdoor recreation and related open space lands, encompass only about 5.3 square miles and therefore, without an extensive reforestation program, it is not possible to achieve the woodland standard under any of the three primary environmental corridor subelements. The thrust of the watershed plan with respect to the woodland standard is not one of meeting the areal requirements but is instead one of minimizing the deficit because of the public acquisition components in each of these subelements, the desired woodland protection could occur under Subelement 1 through use of stringent land use controls.

Wetlands: Standards supporting the adopted land use objectives specify the protection of all wetlands over 50 acres in size as well as all high value wetlands, irrespective of size. All 12 of the wetland areas in the watershed are over 50 acres in size and are in the primary environmental corridor and, therefore, this wetland standard could be met under any of the three corridor protection subelements. Subelement 2 would be more likely to achieve the desired wetland protection than subelement 1 because of the additional selective land acquisition incorporated in the latter. None of the 12 wetland areas would be protected by public ownership under subelement 1, thus requiring a major emphasis on land use controls to achieve the necessary protection. Seven of the 12 wetlands would be protected by ownership under subelement 2. Subelement 3 would be the most effective because under this alternative all of the 12 wetlands would be either in public or private ownership for outdoor recreation and related open space use.

Wildlife Habitat: The adopted land use planning objectives are supported by a standard that calls for maintaining a wholesome wildlife habitat through the protection and sound management of woodland and wetland areas and contiguous lands that normally comprise wildlife habitat. A wholesome wildlife habitat could be maintained in the watershed under any of the primary environmental corridor subelements inasmuch as each subelement contains components that pertain to watershed wildlife habitat both within and outside of the primary environmental corridors. Meeting the wildlife habitat standard is highly dependent on local community action inasmuch as it requires not only the protection of woodland, wetland, and selected contiguous areas but also requires the application of sound management techniques to those areas. Subelement 3 would be most effective in satisfying this standard because of the public acquisition component, followed in order of effectiveness by subelement 2 with its selected acquisition component and subelement 1 with its reliance on existing compatible ownership and land use controls.

Outdoor Recreation Land: An analysis of outdoor recreation needs in the watershed, as described in Chapter IX, Volume 1, of this report, concluded that year 2000 land-oriented outdoor recreational needs can be met by the provision of approximately 10 acres of additional snow skiing area, two 18-hole golf courses encompassing a total area of about 360 acres, and encreased local swimming facilities within the urbanizing portions of the watershed. These land and site requirements for these recreational lands are modest, and sufficient land would be readily available under any of the three subelements, particularly since 13 of the 18 potential outdoor recreation sites in the watershed, including all three of the high value sites, are located within the primary environmental corridors. Provision

Table 16

COMPARISON OF THE RELATIVE ABILITY OF THE ENVIRONMENTAL CORRIDOR SUBELEMENTS TO MEET WATERSHED NATURAL RESOURCES-RELATED STANDARDS AND RECREATIONAL NEEDS

Standard or Need	Environmental Corridor Subelement			Comment
	Subelement 1: Minimum Protection	Subelement 2: Intermediate Protection	Subelement 3: Maximum Protection	
Floodlands: Maintain 100-year recurrence interval floodlands that are unoccupied by or not yet committed to urban development in essentially natural open space condition.	Could be met	Could be met	Met	The standard could be met under Elements 1 and 2 by adoption of floodland regulations that meet minimum requirements of the State of Wisconsin floodland management program and, equally important, incorporate a comprehensive approach to floodland management.
Woodlands: Preserve 10 percent of the watershed land area in woodland.	Cannot be met	Cannot be met	Cannot be met	This standard would require about 13.7 square miles of woodland in the watershed. The total woodlands in the watershed, including those on public and private outdoor recreation and related open space lands, encompass about 5.3 square miles. It is, therefore, not possible to meet the woodland standard.
Wetlands: Protect all wetlands over 50 acres and those with high resource value.	Could be met	Could be met	Met	All 12 of the wetland areas in the watershed measuring over 50 acres in size are in the primary environmental corridor. None of the sites would be protected by ownership under Element 1, 7 would be so protected under Element 2, and all 12 under Alternative 3. The standard could be met under Elements 1 and 2 by the land use control subelement.
Wildlife: Maintain a wholesome habitat.	Could be met	Could be met	Could be met	Meeting this standard is highly dependent on local community action with respect to woodland, wetland, and wildlife habitat management practices.
Outdoor Recreation--Land: Provide approximately 10 acres of additional snow skiing lands, two 18-hole golf courses, and increased local swimming facilities.	Could be met	Could be met	Could be met	Meeting this requirement is highly dependent on private or public acquisition of land on which the needed recreational facilities would be developed. Thirteen of the 18 potential outdoor recreation sites in the watershed are included in the primary environmental corridor. All 13 sites would be available for public development under Element 3, and 7 would be acquired under Element 2. Private acquisition and development for public use would be required under Element 1.
Outdoor Recreation--Water: Upgrade surface water quality so as to permit recreational activities--fishing, boating and wading--on all major streams and tributaries with the exception of Honey Creek, South Branch of Underwood Creek, lower portion of Underwood Creek, and the extreme lower reaches of the Menomonee River.	Could be met	Could be met	Could be met	Upgrading the quality of surface water and the recreational suitability of the riverine areas requires land acquisition and controls as included in Elements 1, 2, and 3 plus development of water quality control facilities.

Source: SEWRPC.

of these necessary supplemental outdoor recreation opportunities is not, therefore, land-limited but is highly dependent on action by local government or private enterprise to acquire the necessary land and to construct and otherwise develop the necessary facilities.

Inasmuch as subelement 1 does not include a public acquisition component, none of the 18 potential park sites would be publicly acquired under that alternative although private acquisition and development for public recreational use would be possible and compatible with this subelement. Subelement 2 would result in the public acquisition of four of the 18 potential outdoor recreation sites in the watershed, including two of the three high value sites, one of the 10 medium value sites, and one of the five low value sites and therefore sufficient sites would be available for meeting the modest additional active recreational land needs of the watershed. Under subelement 3, all 13 of the potential outdoor recreation sites in the corridor would be publicly acquired and, therefore, sufficient suitable land would be available for satisfying the recreational land needs of the watershed.

Just as any of the three primary environmental corridor subelements could meet the year 2000 land-oriented outdoor recreational needs of the watershed, those corridor subelements also could contribute substantially to meeting the water-oriented outdoor recreational needs of the basin. The water quality objectives call for upgrading surface water quality on most of the major streams and tributaries in the watershed so as to permit fishing, boating, and wading activities. The land acquisition and land use control components of the three corridor subelements will increase the availability and the quality of the riverine area lands needed to support the water-oriented recreation while the water control facilities recommended in Chapter IV of this volume will substantially improve the water quality.

Recommended Primary Environmental Corridor Protection Subelement

It is apparent that the adoption and implementation of any one of the three alternative primary environmental corridor subelements could have desirable and far-reaching effects on the quality of life within the Menomonee River watershed, particularly in those areas of the watershed which will be urbanized by 2000. The basic difference between the three alternatives is the amount of public land acquisition and, hence, the degree of assurance of the permanent protection and preservation of the primary environmental corridor areas of the watershed.

It is recommended that the second, or intermediate protection subelement, be included in the recommended comprehensive plan for the Menomonee River watershed. This alternative, while involving a relatively large expenditure for the first or minimum protection subelement, which does not include land acquisition, will provide permanent protection to the highest value corridors through public acquisition of 3,062 acres of high value corridor at a cost of $2,183,050 to supplement the 4,641 acres of primary environmental corridor already in public or private outdoor recreation and related open space use. While the third or maximum protection subelement would provide permanent protection for all 10,439 acres of corridor at an acquisition cost of $14,749,150 for 5,798 acres, the incremental cost—$12,566,100—relative to that of the intermediate protection subelement is probably not warranted in view of the variety of land use controls that are in existence or could be developed for protection of those 2,736 acres of corridor lands that would not be protected by ownership under subelement 2.

Of great significance in the recommendation that the intermediate primary environmental corridor subelement be included in the recommended comprehensive plan for the Menomonee River watershed is the permanent preservation primarily through public ownership of the riverine areas of the watershed along the main stem of the Menomonee River where potential flood damages would be greatest if urban development is further allowed to encroach and where the remaining high-value resources are concentrated. Implementation of the intermediate protection alternative would also provide permanent protection against urban encroachment into the significant headwater resource areas of the watershed and into selected high value woodland, wetland, and wildlife habitat areas—such as the Tamarack Swamp and the Brookfield Swamp—located in the middle reaches of the watershed.

It is important to recognize that the effectiveness of the recommended primary environmental corridor subelement is based in part on the assumption that privately owned lands currently used for recreation and related open space uses will continue to be used for such purposes. Local communities could help to assure such continued use by the careful application of recreational and conservancy zoning. While such zoning is not an absolute guarantee that the lands concerned will remain permanently in recreational and open space use, the application of such zoning will require formal action should a change in use be proposed by the private owners and provide an opportunity for public acquisition.

In addition to zoning and public acquisition in fee simple, other techniques may come into use during the watershed plan implementation period for maintaining privately owned land in uses compatible with primary environmental corridor preservation. Such techniques may include tax incentives to encourage the maintenance of land in agricultural, recreational and other open space uses, deeding the purchase of scenic easements, and development rights.

The area along Underwood Creek in the Village of Elm Grove between Juneau Boulevard on the north and the Village limits on the east represents a unique situation in the watershed in that it comprises a sizeable break or discontinuity in the primary environmental corridor system. This 1.12-mile-long area along Underwood

Creek has been filled and developed for intensive urban uses in a manner so as to render it unsuitable in its present condition for inclusion in the primary environmental corridors of the watershed. This area could be restored to corridor use, however, by providing through redevelopment continuous parkway from Juneau Boulevard downstream to the east limits of the Village. Because of the surrounding land uses this parkway would necessarily have to be an urban-oriented facility that could offer limited outdoor recreational activities such as pleasure walking, while at the same time adding beauty to the urban area and providing for continuity of the primary environmental corridor. Additional comments concerning an urban-oriented corridor restoration along Underwood Creek in the Village of Elm Grove are presented in Chapter IV of this volume in conjunction with a discussion of flood control alternatives for the Village.

ALTERNATIVE PARKWAY DRIVE, SCENIC DRIVE AND RECREATIONAL TRAIL SUBELEMENTS

As noted in Chapter IX, Volume 1, of this report, pleasure driving constitutes the fifth most popular outdoor recreational activity in the Menomonee River watershed, with a forecast year 2000 total participant demand on the peak weekend day of about 12,800 persons, an increase of about 25 percent over the estimated current 1970 total of 10,000 participants. It is important, therefore, to consider parkway and scenic drives as an integral part of the natural resource and recreation-related aspects of the comprehensive watershed plan for the Menomonee River watershed.

Definitions and Concepts

It is important for the planning purposes to distinguish between a parkway, a parkway pleasure drive, a scenic pleasure drive, and a recreational trail. The term "parkway" is defined, for the purposes of this report, as an elongated area of publicly owned park of other land in essentially natural, open use. A parkway usually is located along a stream valley or ridge line and is intended to provide scenic and ecological continuity by linking major park or other open space lands within a total park and recreation system, while preserving in open space uses those lands, such as natural floodlands that should not be developed for intensive urban uses in order to avoid serious environmental and developmental problems.

The term "parkway pleasure drive" is defined for the purposes of this report as a nonarterial roadway established in or immediately adjacent to a parkway. It is important to recognize that parkway pleasure drives and the associated parkway lands are intended to serve such uses as bicycling and pleasure walking in addition to pleasure driving, and accordingly, use by commercial vehicles such as trucks and buses is normally prohibited. Parkways are an excellent way of permanently preserving environmental corridors in urban areas. To achieve this purpose, parkways should encompass essentially all of the high value primary environmental corridor lands. It should be noted, however, that to achieve the objective of environmental corridor preservation, parkways do not have to incorporate parkway pleasure drives. It should also be noted that a parkway pleasure drive may not be so named and may not be maintained by the governmental unit that maintains the associated parkway; that is, the parkway drive concept is a functional as opposed to a jurisdictional concept.

Milwaukee County has developed one of the finest parkway systems in the United States, a system that includes a parkway pleasure drive along the Menomonee River from Hawley Road in the City of Milwaukee upstream to a point about one-quarter mile south of W. Hampton Avenue in the City of Wauwatosa. Similar but shorter and less continuous parkway pleasure drives also parallel Milwaukee County parkways along the Little Menomonee River, Underwood Creek, the South Branch of Underwood Creek, and Honey Creek. Existing Milwaukee County parkway pleasure drives in the Menomonee River watershed have a total length of 14 miles. The Village of Menomonee Falls has developed a one-mile-long segment of parkway pleasure drive along the Menomonee River between Fond du Lac Avenue and Arthur Avenue and additional shorter segments of parkway pleasure drive upstream and along the Tamarack Swamp.

The term "interconnecting streets" may be associated with the term parkway pleasure drives. These streets may be defined as relatively short segments of existing streets in urban areas that serve to interconnect relatively long segments of parkway pleasure drives where the overall continuity of the parkway is interrupted by urban development. While these interconnecting streets are not normally scenic they are widely spaced, and each such segment is relatively short so that their presence does not significantly detract from the overall aesthetic value of the parkway pleasure drive.

While parkway pleasure drives as defined above are certainly scenic, the term "scenic pleasure drive," for the purpose of this report, is reserved for marked routes over existing roadways that traverse aesthetically pleasing geographical areas, including areas of topographic, vegetative, and geological interest, as well as areas that contain significant clusters of sites having historic and cultural interest. An example of a marked scenic drive in the planning Region is the state-established Kettle Moraine Scenic Drive. Generally, scenic drives are more appropriately established in rural areas, while parkway drives are more appropriately established in urban or urbanizing areas.

The term "recreational trail" is defined for the purposes of this report as a linear pathway within a public parkway intended for a variety of recreational uses, such as pleasure walking, bicycling, and horseback riding. The use of such trails by motorized vehicles is generally prohibited because of the conflict with other trail uses and because of the noise problem created in adjacent park and residential areas. There are several examples of recreational trails within the watershed in Milwaukee County parklands including the 0.75-mile-long trail that parallels the Menomonee River between Hoyt Park and the Old Village area of Wauwatosa, 1.3 miles of trail along the Little Menomonee River between W. Hampton Avenue and W. Silver Spring Drive, and a 1.0 mile segment of trail along the Little Menomonee River between W. Leon Terrace and W. Good Hope Road.

Since recreational trails may constitute the first stage in the ultimate construction of parkway pleasure drives, the detailed design of recreational trail alignments should recognize the possibility of future parkway pleasure drives in the same parkway. Recreational trail alignments should be selected so as to be different from and compatible with the likely alignments of future parkway pleasure drives, thus permitting retention of the recreational trails if and when parkway pleasure drives are constructed.

Subelement 1: Parkway Drive-Scenic Drive

A parkway and scenic drive subelement was developed for the Menomonee River watershed for the purpose of maximizing public use and enjoyment of the primary environmental corridors of the watershed, particularly the highest value corridors to be protected by public ownership under the recommended corridor protection subelement. As shown on Map 6, the proposed parkway and scenic drive system would be an extension of, and generally similar to, the extensive parkway system that already exists in the Milwaukee County portion of the watershed. Subelement 1 would be composed of an essentially linear system of parkway pleasure drives, scenic pleasure drives, and interconnecting streets. The lineal extent of the existing and proposed parkway pleasure drives, scenic pleasure drives and interconnecting streets as well as the cost of the proposed parkway drives are summarized by civil division in Table 17.

For purposes of cost estimation, the proposed parkway pleasure drive was assumed to be 24 feet wide to accommodate a single lane of traffic in each direction. A "rural" cross-section was assumed to avoid the cost of curb and gutter, storm water inlet, and storm sewer construction. The unit cost of the assumed parkway drive was estimated at $85,000 per mile, a figure composed of construction costs, engineering and administrative costs, and an allowance for contingencies. An additional $40,000 per mile was included to provide for the construction of bituminous surfaced "off street" parking areas near the parkway drives that would provide about 135 parking spaces per mile of parkway drive. Therefore, the total cost of the parkway pleasure drives and associated parking areas was estimated at $125,000 per mile of parkway pleasure drive. Parkway pleasure drive costs were increased, as needed, to allow for the construction of bridges over waterways, for railway underpasses, and for localized channel realignments.

The Milwaukee County portion of alternative subelement 1 would consist of 14.0 miles of existing parkway pleasure drive located along the Menomonee River, Little Menomonee River, Underwood Creek and South Branch of Underwood Creek, supplemented with 3.6 miles of new parkway drive located along the Menomonee River, 5.4 miles located along the Little Menomonee River, 0.4 miles located along the Underwood Creek, and 0.1 miles located along the South Branch of Underwood Creek. About 2.0 miles of existing connecting urban streets and 0.2 miles of connecting rural roadways would be incorporated into the Milwaukee County portion of the parkway and scenic drive alternative for subelement 1. The total cost of 9.5 miles of proposed new parkway pleasure drives in Milwaukee County was estimated at about $1.9 million, of which about $1.2 million was for parkway drives and about $0.7 million for bridges and other structures. Implementation of this portion of the subelement would provide a total of 25.7 miles of parkway pleasure drive and interconnecting streets within the Milwaukee County portion of the watershed.

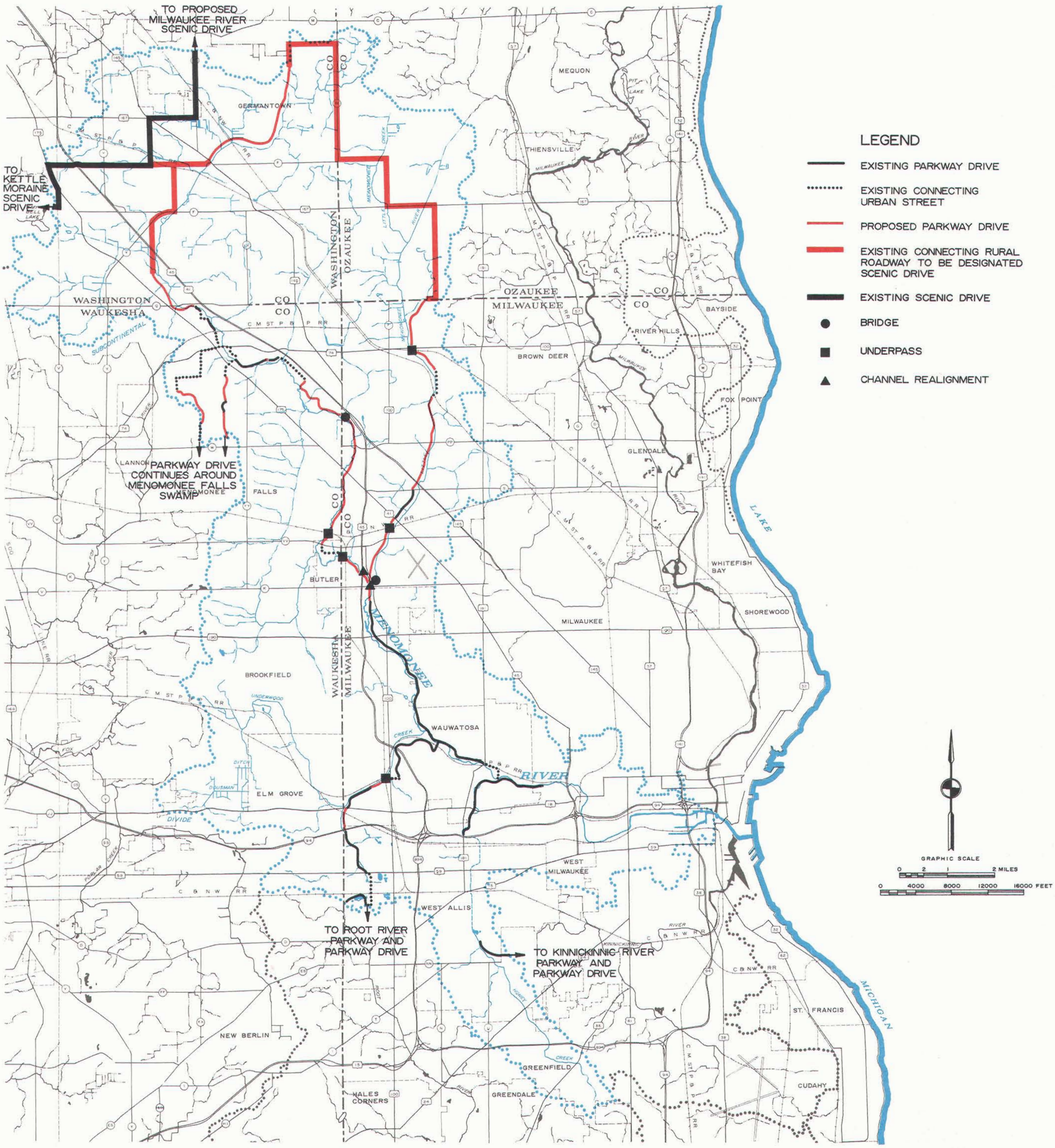
The Ozaukee County portion of alternative subelement 1 would consist solely of 6.1 miles of marked scenic pleasure drives. There would be no construction of parkway pleasure drives because land acquisition suitable for such drives is not included in the recommended primary environmental corridor subelement. In addition to paralleling and traversing the primary environmental corridor lands in Ozaukee County, the proposed scenic drive within this County would provide a connection between the parkway pleasure drives proposed for the Milwaukee and Washington Counties portions of the Menomonee River Watershed.

The Washington County portion of alternative subelement 1 would consist of 4.0 miles of new parkway pleasure drive located along the Menomonee River in the Village of Germantown and 6.9 miles of interconnecting scenic pleasure drive which would also generally follow the Menomonee River. The total cost of the 4.0 miles of proposed new parkway pleasure drives in the Washington County was estimated at about $500,000. This portion of subelement 1 would provide a total of 10.9 miles of parkway and scenic drives within the Washington County portion of the watershed.

The Waukesha County portion of alternative subelement 1 would consist of 2.0 miles of existing parkway pleasure drives, 6.0 miles of new parkway drives, and 5.4 miles of interconnecting streets. The 6.0 miles of new parkway pleasure drive would consist of 3.0 miles located along the Menomonee River, 0.4 miles located along the South Branch of Underwood Creek, and 2.6 miles located around the northern portion of Tamarack Swamp. The total cost of the new parkway pleasure drives was estimated at more than $860,000, including $750,000 for parkway drive construction and $112,500 for a structure. Implementation of this portion of subelement 1 would provide a total of 13.4 miles of parkway pleasure drive and interconnecting streets in the Waukesha County portion of the watershed.

Map 6

PARKWAY DRIVE-SCENIC DRIVE SUBELEMENT FOR THE MENOMONEE RIVER WATERSHED



The system of parkway and scenic drives shown on this map was designed to facilitate public access to and enjoyment of the primary environmental corridors of the Menomonee River watershed. This alternative would provide an interconnected system of about 56 miles of parkway and scenic drives consisting of about 16 miles of existing parkway pleasure drives, 20 miles of new parkway pleasure drives to be constructed at a cost of $3.2 million, 13 miles of scenic pleasure drives routed over existing rural roads, and 7 miles of interconnecting existing urban streets. This alternative parkway drive-scenic drive system was not included in the comprehensive plan for the Menomonee River watershed because of the high estimated cost of the new parkway pleasure drives.

Source: SEWRPC.

Table 17

PARKWAY DRIVE-SCENIC DRIVE AND RECREATIONAL TRAIL SUBELEMENTS FOR THE MENOMONEE RIVER WATERSHED

Location		Subelement 1: Parkway Drive-Scenic Drive					
County	Civil Division	Existing Parkway Drives (Miles)	Existing Connecting Urban Streets (Miles)	Existing Connecting Rural Roadways to be Designated Scenic Pleasure Drives[a] (Miles)	Proposed Parkway Drives[b] Miles	Proposed Parkway Drives[b] Cost in Dollars	Total Length of Parkway Drive-Scenic Drive System (Miles)
Milwaukee	City of Milwaukee	2.6	0.7	0.2	8.5	1,062,500	12.0
	City of Wauwatosa	8.9	0.7	- -	1.0	125,000	10.6
	City of West Allis	2.5	0.6	- -	- -	- -	3.1
Subtotal		14.0	2.0	0.2	9.5	1,187,500	25.7
Ozaukee	City of Mequon	- -	- -	6.1	- -	- -	6.1
Subtotal		- -	- -	6.1	- -	- -	6.1
Washington	Village of Germantown	- -	- -	6.9	4.0	500,000	10.9
Subtotal		- -	- -	6.9	4.0	500,000	10.9
Waukesha	Village of Butler	- -	0.6	- -	0.3	37,500	0.9
	Village of Menomonee Falls	2.0	4.8	- -	5.3	662,500	12.1
	City of Brookfield	- -	- -	- -	0.4	50,000	0.4
Subtotal		2.0	5.4	- -	6.0	750,000	13.4
Total		16.0	7.4	13.2	19.5	2,437,500[d]	56.1

Location		Subelement 2: Recreational Trail-Scenic Drive						
County	Civil Division	Existing Parkway Drives (Miles)	Existing Connecting Urban Streets (Miles)	Existing Connecting Rural Roadways to be Designated Scenic Pleasure Drives[a] (Miles)	Existing Recreational Trails (Miles)	Proposed Recreational Trails[c] Miles	Proposed Recreational Trails[c] Cost in Dollars	Total Length of Parkway Drive - Scenic Drive- Recreational Trail System (Miles)
Milwaukee	City of Milwaukee	2.6	0.2	0.2	2.3	7.3	164,250	12.6
	City of Wauwatosa	8.9	0.7	- -	- -	1.1	24,750	10.7
	City of West Allis	2.5	0.6	- -	- -	- -	- -	3.1
Subtotal		14.0	1.5	0.2	2.3	8.4	189,000	26.4
Ozaukee	City of Mequon	- -	- -	6.1	- -	- -	- -	6.1
Subtotal		- -	- -	6.1	- -	- -	- -	6.1
Washington	Village of Germantown	- -	- -	6.9	- -	4.0	90,000	10.9
Subtotal		- -	- -	6.9	- -	4.0	90,000	10.9
Waukesha	Village of Butler	- -	0.6	- -	- -	0.3	6,750	0.9
	Village of Menomonee Falls	2.0	4.8	- -	- -	5.3	119,250	12.1
	City of Brookfield	- -	- -	- -	- -	0.4	9,000	0.4
Subtotal		2.0	5.4	- -	- -	6.0	135,000	13.4
Total		16.0	6.9	13.2	2.3	18.4	414,000[e]	56.8

Location		Subelement 3: Parkway Drive-Scenic Drive-Recreational Trail									
County	Civil Division	Existing Parkway Drives (Miles)	Existing Connecting Urban Streets (Miles)	Existing Connecting Rural Roadways to be Designated Scenic Pleasure Drives[a] (Miles)	Existing Recreational Trails (Miles)	Proposed Parkway Drive[b] Miles	Proposed Parkway Drive[b] Cost in Dollars	Proposed Recreational Trail[c] Miles	Proposed Recreational Trail[c] Cost in Dollars	Total Length and Cost of Parkway Drive Scenic Drive - Recreational Trails System Miles	Total Length and Cost of Parkway Drive Scenic Drive - Recreational Trails System Cost in Dollars
Milwaukee	City of Milwaukee	2.6	0.2	0.2	2.3	3.0	375,000	4.3	96,750	12.6	471,750
	City of Wauwatosa	8.9	0.7	- -	- -	0.6	75,000	0.5	11,250	10.7	86,250
	City of West Allis	2.5	0.6	- -	- -	- -	- -	- -	- -	3.1	- -
Subtotal		14.0	1.5	0.2	2.3	3.6	450,000	4.8	108,000	26.4	558,000
Ozaukee	City of Mequon	- -	- -	6.1	- -	- -	- -	- -	- -	6.1	- -
Subtotal		- -	- -	6.1	- -	- -	- -	- -	- -	6.1	- -
Washington	Village of Germantown	- -	- -	6.9	- -	4.0	500,000	- -	- -	10.9	500,000
Subtotal		- -	- -	6.9	- -	4.0	500,000	- -	- -	10.9	500,000
Waukesha	Village of Butler	- -	0.6	- -	- -	0.3	37,500	- -	- -	0.9	37,500
	Village of Menomonee Falls	2.0	4.8	- -	- -	5.3	662,500	- -	- -	12.1	662,500
	City of Brookfield	- -	- -	- -	- -	- -	- -	0.4	9,000	0.4	9,000
Subtotal		2.0	5.4	- -	- -	5.6	700,000	0.4	9,000	13.4	709,000
Total		16.0	6.9	13.2	2.3	13.2	1,650,000	5.2	117,000	56.8	1,767,000[f]

[a] *Does not include 7.1 miles of the proposed Southern Lakes Scenic Drive in the Washington County portion of the watershed.*

[b] *A 24-foot wide, two-lane bituminous pavement without curb, gutter, and storm sewer with a unit capital cost, including engineering and contingencies of $125,000 per mile of parkway pleasure drive.*

[c] *An 8-foot wide bituminous pavement with a unit capital cost, including engineering and contingencies, of $22,500 per mile.*

[d] *Increase by $807,500 for a total Plan Element 1 cost of $3,245,000 to account for the following facilities in Milwaukee County: Two bridges at a cost of $225,000, four underpasses beneath railroad embankments at a cost of $450,000, and two channel realignments at a cost of $20,000 plus one underpass beneath a railroad embankment in Waukesha County at a cost of $112,500.*

[e] *Increase by $247,500 for a total Plan Element 2 cost of $661,500 to account for the following facilities in Milwaukee County: Two bridges at a cost of $75,000, three underpasses beneath railroad embankments at a cost of $125,000 and two channel realignments at a cost of $10,000 plus one underpass beneath a railroad embankment in Waukesha County at a cost of $37,500.*

[f] *Increase by $545,000 for a total Plan Element 3 cost of $2,312,000 to account for the following facilities in Milwaukee County: Two bridges at a cost pf $225,000, three underpasses beneath railroad embankments at a cost of $187,500, and two channel realignments at a cost of $20,000 plus one underpass beneath a railroad embankment in Waukesha County at a cost of $112,500.*

Source: SEWRPC.

Considering the Menomonee River watershed as whole, alternative subelement 1 would provide an interconnected system of 56.1 miles of environmental corridor-oriented parkway pleasure drives and scenic pleasure drives. The system would be composed of 16.0 miles of existing parkway pleasure drive; 19.5 miles of new parkway pleasure drive to be constructed at a total estimated cost of about $3.2 million, including bridges and other structures; 13.2 miles of scenic pleasure drives routed over existing rural roads; and 7.4 miles of existing urban streets.

The parkway pleasure drive-scenic pleasure drive system envisioned under alternative subelement 1 could be connected to similar systems located in adjacent watersheds. As shown on Map 6, the existing parkway and pleasure drives in the southern portion of the Menomonee River watershed could be directly connected to parkways and parkway pleasure drives in the adjacent Root River and Kinnickinnic River watersheds. The Southern Lakes Scenic Drive which traverses the extreme northwest corner of the watershed is part of the adopted jurisdictional highway system plan for Washington County[6] and is intended to provide a scenic link between the proposed Milwaukee River Scenic Drive which lies north of the Menomonee River watershed and the existing Kettle Moraine Scenic Drive which lies to the west of the Menomonee River watershed. The parkway drive-scenic drive system proposed for the Menomonee River watershed under alternative subelement 1 would be connected to the southern lakes scenic drive as shown on Map 6.

Subelement 2: Recreational Trail-Scenic Drive

A recreational trail-scenic drive subelement was developed as one alternative to the parkway drive-scenic drive subelement. This alternative was designed to provide convenient public access to the primary environmental corridors of the watershed, particularly the corridor lands that would be newly purchased under the recommended corridor protection subelement, at a lower cost than the parkway drive-scenic drive subelement. As shown on Map 7, the recreational trail-scenic drive subelement would be similar to the parkway drive-scenic drive subelement in alignment, but less costly recreational trails would be used in place of parkway drives to provide the desired public access. The net effect would be to replace the 19.5 miles of parkway drives proposed in alternative subelement 1, having an estimated capital cost of about $3.2 million, with 18.4 miles of recreational trails having a total estimated capital cost of about $661,500, including structures. The lineal extent of the existing parkway pleasure drives, scenic pleasure drives and interconnecting streets as well as the cost of the proposed recreational trails are summarized by civil division in Table 17.

[6] *A Jurisdictional Highway System Plan for Washington County*, *SEWRPC Planning Report No. 23, October 1974.*

For purposes of cost estimation, the proposed recreational trails were assumed to be six to eight feet wide with a bituminous surface. The unit cost of the recreational trails was estimated at $22,500 per mile—or about $4 per lineal foot—excluding structures.

The Milwaukee County portion of subelement 2 would consist of 14.0 miles of existing parkway pleasure drive along the Menomonee River, Little Menomonee River, Underwood Creek, and the South Branch of Underwood Creek supplemented with 3.6 miles of new recreational trail along the Menomonee River, 4.3 miles along the Little Menomonee River, 0.4 miles along Underwood Creek, and 0.1 miles along the South Branch of Underwood Creek for a total of 8.4 miles of proposed new recreational trail. About 1.5 miles of existing interconnecting streets and 0.2 miles of rural roadways along with 2.3 miles of existing recreational trails along the Little Menomonee River, would be incorporated into the Milwaukee County portion of the supplemental recreational trail in subelement 2. The cost of the 8.4 miles of proposed new recreational trail in Milwaukee County was estimated at about $189,000 plus $210,000 for structures for a total cost of $399,000.

The Ozaukee County portion of subelement 2 would consist solely of 6.1 miles of marked scenic pleasure drive. There would be no construction of recreational trails in this county inasmuch as land acquisition in this portion of the watershed is not included in the recommended primary environmental corridor subelement.

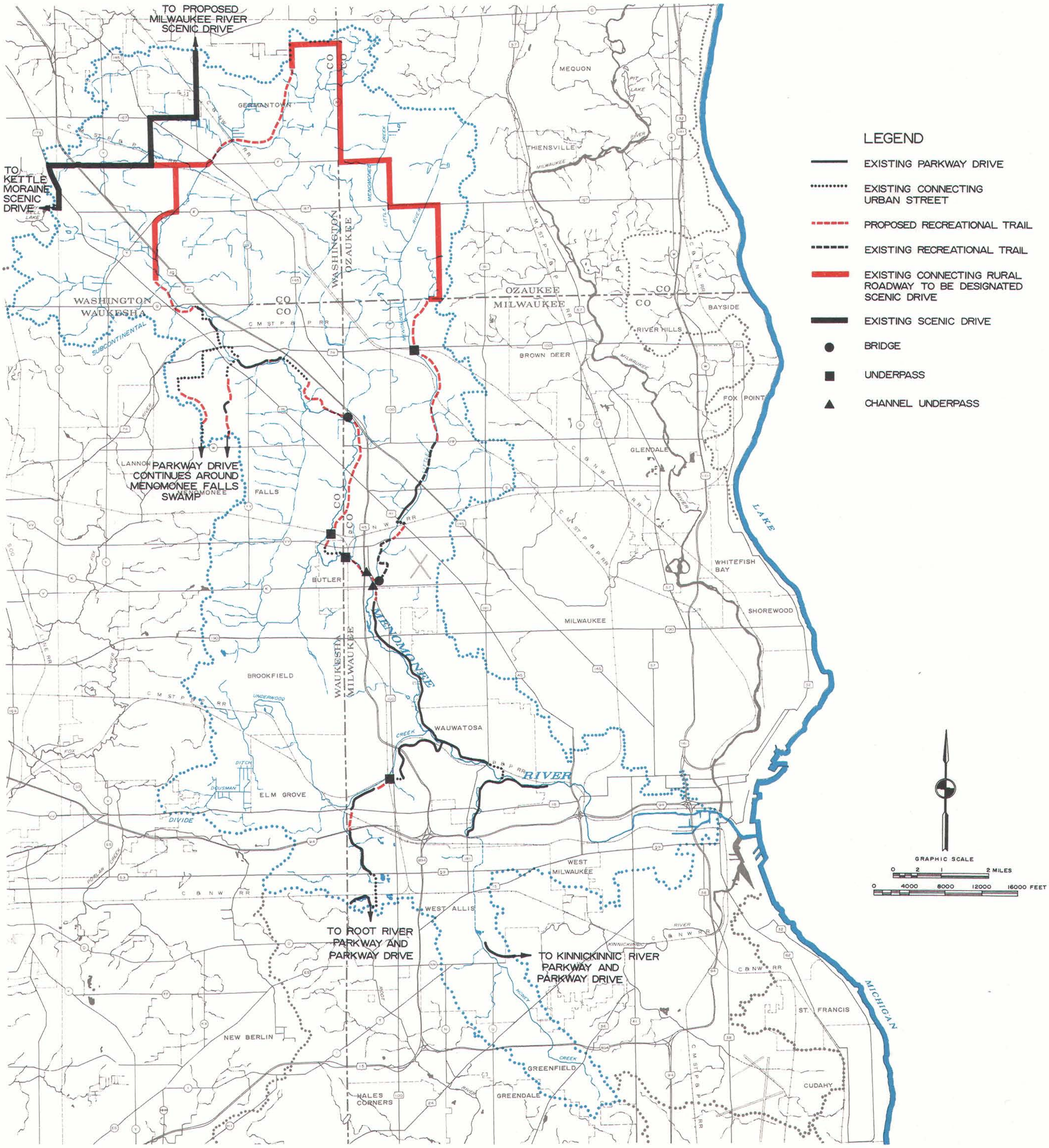
The Washington County component of subelement 2 would consist of 4.0 miles of new recreational trail along the Menomonee River in the Village of Germantown, in combination with 6.9 miles of interconnecting scenic pleasure drive which would also generally follow the Menomonee River and provide a connection to the proposed Southern Lakes Scenic Drive that traverses the northwest portion of the Village. The cost of the 4.0 miles of proposed new recreational trail in the Washington County portion of the watershed was estimated at about $90,000.

The Waukesha County portion of subelement 2 would consist of 3.0 miles of new recreational trail along the Menomonee River, 0.4 miles of new recreational trail along the South Branch of Underwood Creek, and 2.6 miles of new recreational trail adjacent to the northern portion of the Tamarack Swamp, for a total of 6.0 miles of new recreational trail. The proposed trails would be connected to the 2.0 miles of existing parkway pleasure drive in Waukesha County by means of 5.4 miles of existing interconnecting streets. Costs for the 6.0 miles of proposed new recreational trail in the Waukesha County portion of the watershed were estimated at about $135,000 plus $37,500 for a structure for a total cost of $172,500.

Considering the Menomonee River watershed as a whole, alternative subelement 2—the supplemental recreational trail alternative—would consist of an interconnecting

Map 7

RECREATIONAL TRAIL-SCENIC DRIVE SUBELEMENT FOR THE MENOMONEE RIVER WATERSHED



The system of recreational trails and scenic drives shown on this map was developed as an alternative means for providing public access to the primary environmental corridors of the watershed. The approximately 57-mile-long recreational trail-scenic drive system would consist of about 16 miles of existing parkway pleasure drives, 2 miles of existing recreational trails, 19 miles of new recreational trails to be constructed at a cost of $0.7 million, 13 miles of scenic pleasure drives routed over existing rural roads, and 7 miles of interconnecting existing urban streets.

Source: SEWRPC.

system of 56.8 miles of corridor-oriented parkway pleasure drives, scenic pleasure drives, interconnecting streets and roadways, and recreational trails. The system would be composed of 16.0 miles of existing parkway pleasure drives 13.2 miles of scenic pleasure drives using existing roadway, 6.9 miles of interconnecting streets using existing urban routes, 2.3 miles of existing recreational trails, and 18.4 miles of new recreational trails to be constructed at an estimated cost of about $661,500 which includes structures.

Subelement 3: Parkway Drive-Scenic Drive-Recreational Trail

A third alternative subelement was developed for the specific purpose of providing convenient public access to the primary environmental corridors, particularly the corridor lands that would be newly purchased under the recommended corridor protection subelement which recognizes the recent reluctance of Milwaukee County to expend funds for the construction of additional parkway pleasure drives in the County. To that end, alternative subelement 3 limits the construction of new parkway pleasure drives within Milwaukee County to those needed to complete the gaps in the existing parkway pleasure drive system while proposing the construction of recreational trails for the remaining corridor lands within Milwaukee County in order to provide a high level of public access at a minimum cost. Alternative subelement 3 envisions the construction of parkway pleasure drives in the Waukesha and Washington County portions of the watershed in recognition of the general lack of and need for such drives in those areas. Alternative subelement 3, the parkway drive-scenic drive-recreational trail alternative, is in effect a combination of alternative subelements 1 and 2. The spatial arrangement of the parkway pleasure drives, scenic pleasure drives, recreational trails, and interconnecting urban streets is shown on Map 8, whereas the lineal extent of these various features and their costs by civil division are summarized in Table 17.

The Milwaukee County portion of alternative subelement 3 would consist of 14.0 miles of existing parkway pleasure drive along the Menomonee River, Little Menomonee River, Underwood Creek and South Branch of Underwood Creek supplemented with 3.6 miles of new parkway pleasure drive located along the Menomonee River. There would also be 4.3 miles of new recreational trail located along the Little Menomonee River, 0.4 miles located along the Underwood Creek, and 0.1 miles along the South Branch of Underwood Creek. About 1.5 miles of existing interconnecting streets, 2.3 miles of existing recreation trails, and 0.2 miles of rural roadways would be incorporated into the Milwaukee County portion of subelement 3. The construction costs of the 3.6 miles of proposed new parkway drive in Milwaukee County are estimated at $450,000, and the construction cost of the 4.8 miles of the proposed new recreational trail is estimated at about $108,000. Construction of structures would increase the costs by $432,500, giving a total cost for the proposed parkway drives and recreational trails of about one million dollars.

The Ozaukee County portion of subelement 3 would consist solely of 6.1 miles of marked scenic pleasure drive. There would, therefore, be no construction of parkway pleasure drives or recreational trails in this county because the recommended primary environmental corridor subelement does not include land acquisition in the Ozaukee County portion of the watershed.

The Washington County component of subelement 3 would consist of 4.0 miles of new parkway pleasure drive located along the Menomonee River in the Village of Germantown and 6.9 miles of interconnecting scenic pleasure drive which would also generally follow the Menomonee River. There would be no recreational trails in the Washington County portion of the watershed. Construction costs for the 4.0 miles of proposed parkway pleasure drives in the Washington County portion of the watershed are estimated at $500,000. This subelement would provide a total of 10.9 miles of parkway and scenic drives within the Washington County portion of the watershed.

The Waukesha County portion of subelement 3 would consist of 2.0 miles of existing parkway pleasure drives, 5.6 miles of new parkway pleasure drives, and 5.4 miles of interconnecting streets. There would be only 0.4 miles of recreational trails proposed along the South Branch of Underwood Creek in the Waukesha County portion of the watershed. The 5.6 miles of new parkway pleasure drive would consist of 3.0 miles located along the Menomonee River and 2.6 miles located around the northern portion of the Tamarack Swamp, and have an estimated cost of $700,000 plus $112,500 for a new structure giving a total cost of $812,500. An additional $9,000 would be estimated for the recreational trails proposed. The Waukesha County total is $821,500. Implementation of this subelement would provide a total of 13.4 miles of parkway pleasure drive, interconnecting streets, and proposed recreational trails in the Waukesha County portion of the watershed.

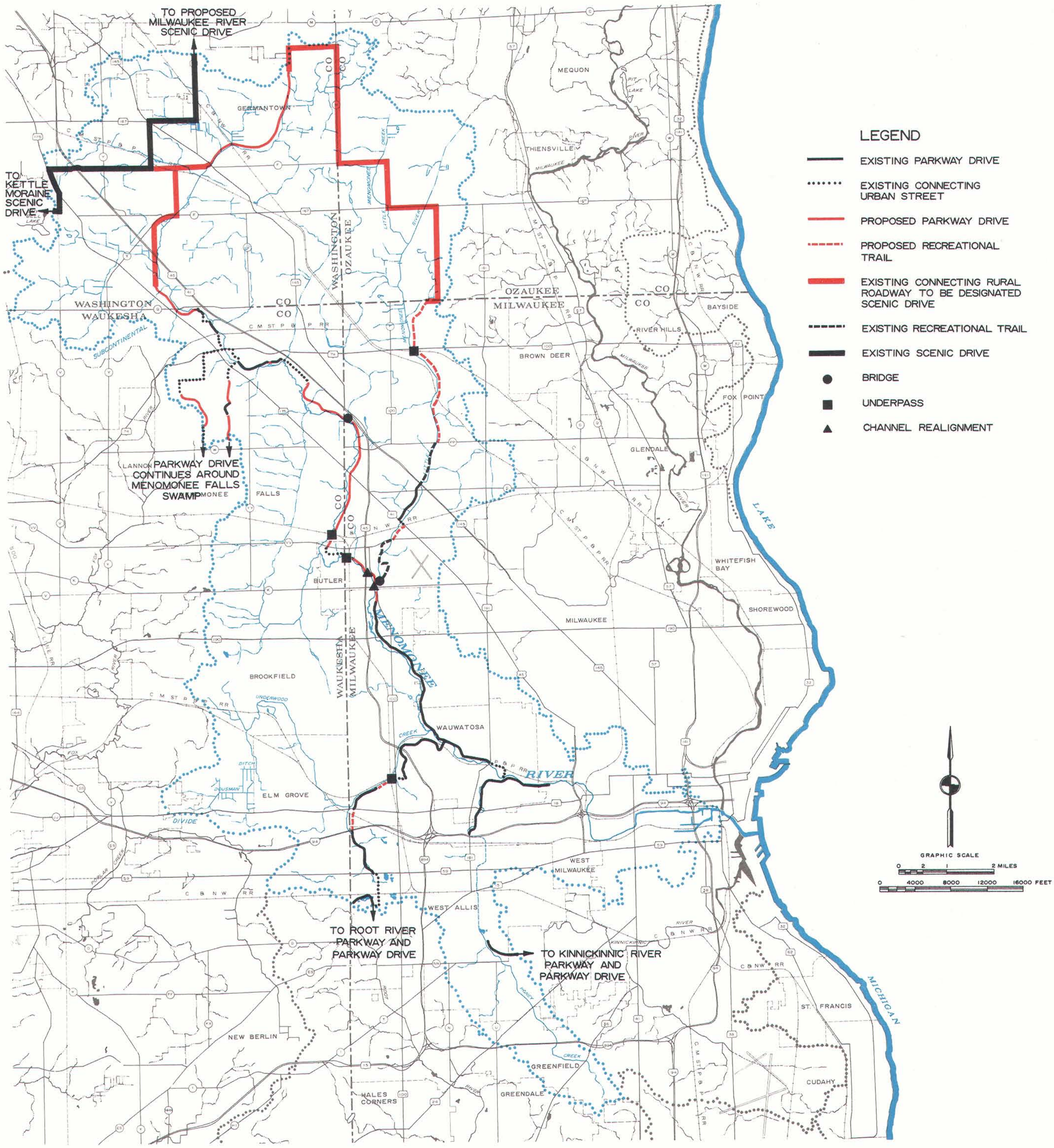
Considering the Menomonee River watershed as a whole, subelement 3 would provide an interconnected system of 56.8 miles of environmental corridor-oriented parkway pleasure drives, scenic pleasure drives, recreational trails and interconnecting urban streets. The system would be composed of 16.0 miles of existing parkway pleasure drive, 13.2 miles of new parkway pleasure drive, 2.3 miles of existing recreational trails, 5.2 miles of new recreational trail, 13.2 miles of scenic pleasure drives routed over existing rural roads, and 6.9 miles of existing urban streets. The new parkway pleasure drives and recreational trails would be constructed at a total estimated cost of about $2.3 million, which includes structures.

Recommended Parkway Drive-Scenic Drive-Recreational Trail Subelement

It is apparent that the adoption and implementation of alternative subelement 1—the parkway drive—scenic drive alternative; alternative subelement 2—the recreational trail-scenic drive alternative; or alternative subelement 3—the parkway drive-scenic drive—recreational

Map 8

PARKWAY DRIVE-SCENIC DRIVE-RECREATIONAL TRAIL SUBELEMENT FOR THE MENOMONEE RIVER WATERSHED



The system of parkway drives, scenic drives, and recreational trails shown on this map was recommended for inclusion in the comprehensive plan for the Menomonee River watershed to provide public access to and enjoyment of the primary environmental corridors of the watershed. The approximately 57 mile system consists of about 16 miles of existing parkway pleasure drives, two miles of existing recreational trails, 13 miles of new parkway pleasure drives and 6 miles of new recreational trails to be constructed at a cost of $2.3 million in addition to 13 miles of scenic pleasure drives routed over existing rural roads and 7 miles of interconnecting urban streets. The recommended parkway drive-scenic drive-recreational trail system provides a continuous route within the Menomonee River watershed and also has direct connection with existing and proposed pleasure drives in the adjacent Root, Kinnickinnic, and Milwaukee River watersheds.

Source: SEWRPC.

trail alternative would complement the recommended intermediate protection primary environmental corridor subelement. All three subelements would provide public access to the riverine area lands that would be required for public park and open space use. However, the three parkway-scenic drive-recreational trail subelements differ significantly in cost and in the type and level of access provided. The capital cost of alternative subelement 1 is estimated at $3.25 million, the capital cost of alternative subelement 2 is estimated at $0.66 million, and the cost of alternative subelement 3 is estimated at $2.31 million. Although all three alternatives are linked to the existing parkway pleasure drives in the basin and in adjacent watersheds, alternative subelement 1—the parkway pleasure drive-scenic drive alternative—would provide the most effective, continuous system of parkway pleasure drives and scenic drives throughout the watershed in that it could be completely traversed by automobile. Alternative subelement 1 could, therefore, be expected to permit more people to have ready access to and use of the 7,703 acres of public or private recreational and open space lands that would be available under the recommended primary environmental corridor subelement. Alternative subelement 2 would lack continuity with respect to automobile use while alternative subelement 3 would, with the exception of the Little Menomonee River within Milwaukee County, provide watershedwide continuity with respect to automobile use.

Although alternative subelement 1 would be the most effective in providing public access to environmental corridor lands, the Watershed Committee believed it important to recognize the recent reluctance of Milwaukee County to expend significant additional funds on the construction of parkway pleasure drives. To that end, it was considered more practical to recommend an alternative that minimizes the construction of parkway pleasure drives within Milwaukee County while providing for the construction of such pleasure drives along the main stem of the Menomonee River in the Washington and Waukesha Counties portion of the basin. While the Milwaukee County portion of the watershed already has an extensive parkway and parkway pleasure drive system, such a system does not exist in the three other counties contained partially within the watershed even though the additional urbanization within the basin will occur primarily in those three counties.

It was accordingly recommended that alternative subelement 3, the parkway drive-scenic drive-recreational trail alternative, be included in the comprehensive plan for the Menomonee River watershed. This alternative, while involving a lower capital expenditure than alternative subelement 1 and a larger expenditure than alternative subelement 2, would provide a better opportunity for a larger proportion of the future population of the watershed to gain access to and to enjoy the aesthetic and recreational benefits of the watershed's primary environmental corridors as protected under the recommended corridor protection subelement. This is particularly true for those presently rural or sparsely populated urban portions of the basin that may be expected to become completely urbanized by the year 2000.

The synthesis and comparison of alternative pleasure drive-scenic drive-recreational trail alternatives are based, in part, on a prescribed width for parkway pleasure drives and recreational trails and on an assumed unit cost for each. It is important to note that the sizes and costs were selected primarily to permit a description of the parkway pleasure drives and recreational trails and to facilitate a comparison of costs among the three alternatives. Although the sizes and unit costs were selected as being representative of current parkway drive and recreational trail construction practice, these sizes and costs are subject to refinement during plan implementation. In some portions in the watershed, for example, it may be desirable to use a staged approach to the development of the recommended parkway pleasure drives and recreational trails in that a portion of drive or trail might be initially constructed at a relatively low unit cost with a gravel surface and the asphalt surface applied at a later date. Similarly, local construction conditions and intended uses may result in the construction of drive or trail segments having widths different from those assumed during preparation of this report.

In its deliberations concerning the selection of a parkway drive-scenic drive-recreational trail subelement, the Menomonee River Watershed Committee considered the possible effects of alternative pleasure drive recommendations on motor fuel consumption in a time of public concern over increasing costs and decreasing availability of petroleum and petroleum products. In Committee deliberation on this matter, concern was expressed that the construction of additional parkway pleasure drives might encourage more pleasure driving and thereby result in increased consumption of motor fuel. It also was noted, however, that public response to increases in the cost of motor fuel may not necessarily take the form of a decrease in the overall use of motor vehicles, but may instead be reflected in changes in the size and efficiency of the vehicles, thereby achieving a reduction in motor fuel consumption while maintaining overall levels of travel as measured in vehicle miles. Pleasure driving is, moreover, a very popular recreational activity and one expected to maintain its popularity over time. Consequently, if increased motor fuel costs did result in a decrease in the overall use of motor vehicles, it would still not necessarily follow that pleasure driving would decrease substantially, since vehicle owners might choose to maintain their level of pleasure driving while reducing the use of their vehicles for other trip purposes. Finally, the Committee noted that it may be prudent to provide improved local opportunities for pleasure driving in a time of increasing motor fuel costs, so as to reduce the need to seek pleasure driving opportunities at great distances from population centers, and thereby reduce the length of pleasure trips and correspondingly reduce the amount of motor fuel used in making such trips. The Committee accordingly concluded that construction of additional parkway pleasure drives was not necessarily inconsistent with the contemporary public concern over the availability and cost of motor fuel.

SUMMARY

The amount of land devoted to urban use within the Menomonee River watershed is forecast to increase from the 1970 total of about 73 square miles, or about 54 percent of the total area of the watershed, to about 88 square miles, or about 65 percent of the total area of the watershed by the year 2000. It is extremely important that this new urban development be related sensibly to soil capabilities; to long-established utility systems; to the delineated floodlands of the Menomonee River system; and to the wetlands, woodlands, and wildlife habitats of the watershed. If such new urban development is not so related, the already severe developmental and environmental problems of the watershed may be expected to continue to intensify and the quality of life for existing and future watershed residents will be lessened.

The recommended land use plan element constitutes a major element of the comprehensive plan for the development of the Menomonee River watershed. The recommended watershed land use plan is set within the context of, and reflects, the concepts and recommendations contained in the revised and updated regional land use plan. The revised and updated regional and watershed development objectives and standards are intended to guide and shape the spatial distribution of land uses within the watershed in order to achieve a safer and a more healthful, pleasant, and efficient land use pattern, while meeting the net land use demand requirements previously set forth. The land use plan element emphasizes efficient utility services, cohesive urban development on suitable soils, preservation of prime agricultural lands, preservation of unique resource areas, and protection of floodland areas from urban encroachment.

Under the recommended watershed land use plan element, residential development would be channeled into low-, medium-, and high-density residential areas properly located with respect to the natural resource base elements and public utility service areas. In addition, prime agricultural lands, environmental corridor areas, and potential park sites would be protected from incompatible development. Specific regulations would govern the use of surface waters and of floodlands. Existing land uses and structures not developed in conformance with these proposals would be considered nonconforming, and regulations would provide for their eventual discontinuance or removal. The attainment of a sound land use pattern throughout the watershed, as well as within the riverine areas, is a basic objective of the comprehensive watershed plan.

In the adaption and refinement of the revised and updated regional land use plan for the Menomonee River watershed, three alternative subelements were considered for protection of the 10,439 acres of primary environmental corridor in the watershed. Subelement 1—the minimum protection alternative—would consist essentially of using land use controls to protect those primary environmental corridor lands not already protected by public or private outdoor recreation and related use. Subelement 2—the intermediate protection alternative—would incorporate selective public acquisition of the highest value corridor lands at a cost of $2,183,050 in combination with land use controls to supplement the protection afforded by existing ownership. Subelement 3—maximum protection alternative—would utilize public acquisition of all primary environmental corridor lands not already in public or private outdoor recreation or related open space use at a cost of $14,749,150. Each of the three corridor protection subelements include a component that calls for the application of sound management techniques to all woodlands, wetlands, and wildlife habitat.

The primary environmental corridor protection subelement recommended for incorporation into the comprehensive watershed plan is the second or intermediate protection alternative. This alternative recommends the public acquisition for resource conservation, recreation, and related open space purposes of all of the remaining undeveloped primary environmental corridors of the watershed lying along the main stem of the Menomonee River in Waukesha and Washington Counties and of certain selected additional environmental corridor lands containing high value resource elements throughout the watershed.

This subelement would serve to permanently protect through public acquisition a total of 3,062 acres, or over 29 percent of the primary environmental corridors of the watershed, covering over 3 percent of the total watershed area. Existing public and private outdoor recreation and related open space lands total 4,641 acres, or about 45 percent of the total primary environmental corridor in the watershed and approximately 5 percent of the watershed area. The remaining 2,736 acres of the primary environmental corridors of the watershed would be protected through appropriate agricultural, shoreland, floodland, conservancy, and low-density residential zoning.

Of the 18 potential recreation and related open space sites within the watershed, 13 sites are located within the recommended corridor protection subelement. That portion of the primary environmental corridor lands slated for public acquisition under this subelement would include 4 of these 13 sites, including 2 of the highest value sites. The remaining nine sites within the corridor would be protected by existing or proposed floodland and conservancy zoning. Inasmuch as the land required for development of facilities to meet forecast land-oriented outdoor recreational demands in the watershed is relatively small, those demands could be easily satisfied by developing some of the potential outdoor recreation sites available under the recommended corridor protection subelement. That subelement, in combination with the recommended water control facility subelement, also would contribute significantly to meeting the water-oriented recreation needs of the watershed. Therefore, under the recommended corridor protection subelement, the total recreational user demand in the watershed would be met, and damaging overuse of the facilities and the concomitant damaging effect on the resource base thereby avoided. Not only would the residents of the watershed be provided with sufficient recreation areas to meet their day-to-day needs, but such needs would be met without extensive conflict between the recreation users within the watershed.

This subelement would serve to permanently protect, through public acquisition, 1,566 acres of woodlands and wetlands that are currently not in public or private outdoor recreation and related open space use, or about 57 percent of the remaining unprotected watershed woodlands and wetlands. In addition, about 2,292 acres of wildlife habitat area, or about 25 percent of the watershed wildlife habitat areas identified throughout the watershed, would be permanently protected through public acquisition.

Three parkway drive-scenic drive-recreational trail subelements were developed for the watershed in order to provide for public use and enjoyment of the primary environmental corridors of the watershed as those corridors would be protected under the recommended corridor protection subelement. Subelement 1—the parkway drive-scenic drive alternative—would consist of the continuous system of 16.0 miles of existing parkway pleasure drive, 19.5 miles of new parkway pleasure drive to be constructed at a cost of $3.25 million, 13.2 miles of scenic pleasure drive routed over existing rural roads, and 7.4 miles of existing interconnecting urban streets. Subelement 2—the recreational trail-scenic drive alternative—would consist of a continuous sytem of 16.0 miles of existing parkway pleasure drives, 18.4 miles of new recreational trails to be constructed at a cost of $0.66 million, 2.3 miles of existing recreational trails, 13.2 miles of scenic pleasure drives routed over existing rural roads, and 6.9 miles of interconnecting existing urban streets. Subelement 3—the parkway drive-scenic drive-recreational trail alternative—would consist of a continuous system of 16.0 miles of existing parkway pleasure drives, 13.2 miles of new parkway pleasure drives and 5.2 miles of new recreational trails to be constructed at a cost of $2.31 million, 2.3 miles of existing recreational trails, 13.2 miles of scenic pleasure drives routed over existing rural roads, and 6.9 miles of existing urban streets.

The parkway drive-scenic drive-recreational trail subelement recommended for incorporation into the comprehensive watershed plan is subelement 3. The key feature of this recommended subelement is the 13.2 miles of additional parkway pleasure drives to be constructed primarily in the Washington and Waukesha County portions of the watershed along the main stem of the Menomonee River where extensive primary environmental corridor lands would be acquired for public use under the watershed plan. The recommended system of parkway drives, scenic pleasure drives, and recreational trails will provide ready access to and will enhance the enjoyment of the protected primary environmental corridors and provide the continuity necessary to accommodate anticipated year 2000 demand for pleasure driving and related outdoor recreational activities in the Menomonee River watershed.

Chapter IV

ALTERNATIVE FLOODLAND MANAGEMENT MEASURES

INTRODUCTION

The inventory and analysis phases of the Menomonee River watershed planning program have identified certain water resource and water resource-related problems, including flooding and water pollution. As stated in Chapter I, Volume 1, the overriding objective of the Menomonee River watershed planning program is to assist in the abatement of these water resource and water resource-related problems by developing a workable plan which can be used to guide development within the watershed into a safer, more healthful, and more economic pattern, a pattern which is properly related to the sustaining ability of the underlying natural resource base without intensifying existing or creating new socio-environmental problems.

The purpose of this chapter is to present alternative floodland management plan subelements from which an integrated water resource management plan for the watershed can be synthesized. The alternative structural and nonstructural floodland management plan subelements described herein were designed for, and should be considered as adjuncts to, the basic land use development proposals advanced in Chapter III of this volume to facilitate the attainment of regional and watershed development objectives. The floodland management plan subelements are thus subordinate to the basinwide land use plan element, and the incremental benefits and costs of these subelements can be separated from those of the basin-wide land use plan element.

As noted in Chapter I of this volume, the evaluation of a particular watershed plan subelement relative to other alternatives intended to resolve an identified problem is a sequential process during which the plan subelement is subjected to several levels of review and evaluation including technical, economic, financial, legal, and administrative feasibility and political acceptability. In anticipation of making a comparative evaluation of the various alternative floodland management plan subelements and to facilitate selection of a recommended comprehensive watershed plan, the technical, economic, and environmental aspects of each alternative floodland management plan subelement are presented in this chapter.

Concerning organization of the material presented in this chapter: Structural and nonstructural floodland management measures available for resolution or prevention of flood problems are described, followed by a discussion of the hydrologic, hydraulic, and economic consequences of alternative land use-floodland development conditions in the Menomonee River watershed. Floodwater storage and diversion alternatives are then described, followed by a comparison of structural flood control measures for selected flood-prone communities. Bridge and culvert alteration is discussed, followed by a description of alternative nonstructural plan subelements recommended for application throughout the watershed. The chapter concludes with a discussion of accessory floodland management measures.

AVAILABLE FLOODLAND MANAGEMENT MEASURES

As urban development within the Menomonee River watershed continues, the problems and monetary losses associated with flooding, in the absence of a sound floodland management program, can be expected to increase. Because of the degree to which urban development has already occurred within the basin, the Menomonee River system, as it exists today, generates relatively high peak flood flows which occur in late winter and in the spring and summer seasons and are caused primarily by rainfall activity. Further indiscriminate urban development within and outside of the watershed floodlands can be expected to increase both the size of, and the damage produced by, floods. Because urbanization increases both the volume and rate of runoff, because floodland storage is so vital in reducing flood peaks, and because sound land use development in relation to the riverine areas of the watershed is so essential to the prevention of flood damage, the basic flood control plan element in any comprehensive plan for the watershed must consist of proposals for sound land use development, not only in the riverine areas, but in the watershed as a whole. Such land use proposals had been set forth for the Menomonee River watershed in Chapter III of this volume. As already noted, the floodland management alternatives set forth herein are proposed as possible adjuncts to the basic land use development proposals.

Floodland management may be defined as the planning and implementation of a combination of measures intended to reconcile the floodwater conveyance and storage function of floodlands with the space and related socioeconomic needs of a resident population. Specific purposes of floodland management include elimination of loss of life, lessening of danger to human health and safety, minimization of monetary damage to private and public property, reduction in the cost of utilities and services, and minimization of disruption in community affairs. A broader goal is the enhancement of the overall quality of life of the watershed residents by protection of those environmental values—recreational, aesthetic, ecological, and cultural—normally associated with, and concentrated in, riverine areas.

Preparation of a floodland management plan for a watershed involves the development of alternative plan subelements, a comparative evaluation of those subelements, and the synthesis of the most effective subelements into an integrated plan. The floodland management plan for the Menomonee River watershed is specifically intended to achieve the land use development objectives, sanitary sewerage system development objectives, and water control facility development objectives and supporting standards set forth in Chapter II of this volume.

The techniques of floodland management may be broadly subdivided into two categories: structural measures and nonstructural measures. Structural measures include floodwater storage facilities such as reservoirs and impoundments, diversions, floodwater containment facilities such as earthen dikes and concrete floodwalls, floodwater conveyance facilities such as major channel modifications, and bridge and culvert modifications or replacements. Nonstructural measures include reservation of floodlands for recreational and open space uses, floodland use regulations, land use controls outside of the floodlands, flood insurance, lending institution policies, realtor policies, community utility policies, emergency programs, and structure floodproofing and removal. Table 18 lists structural and nonstructural measures of floodland management that may apply, individually or in combinations, to portions of the Menomonee River watershed and summarizes the function of each. Structural measures tend to be more effective in achieving the objectives of floodland management in riverine areas that have already been urbanized while nonstructural measures are preventative in that they are generally more effective in riverine areas that have not yet been converted to flood-damage-prone rural and urban development but have the potential for such development.

Structural Measures

Each of the five structural floodland management measures set forth in Table 18 is discussed briefly below. Emphasis is placed on the function of each measure, key factors, or basic requirements used to determine if the given alternative applies to a particular riverine area or portion of the watershed, and on some of the more significant positive and negative features of each measure.

Storage: From the perspective of floodland management, the function of floodwater storage facilities is to detain floodwaters upstream of flood-prone areas for subsequent gradual release, thereby substantially decreasing downstream discharges and stages and, consequently, flood damage. A key factor in the potential application of this alternative is the existence of sites of sufficient volume that are positioned upstream of all, or a significant portion, of the flood-prone riverine areas and are located so as to control the runoff from a significant portion of the total watershed area tributary to the flood-prone areas. In addition, the site must be "available" in the sense that it does not contain significant urban development.

Floodwater storage facilities may be directly located on the stream system, such as is the case with a conventional reservoir, or may be located off the channel system, as in an abandoned quarry or in excavated chambers in the underlying bedrock. In the latter case the floodwaters are diverted to the storage area during a flood event and later returned to the stream by pumping.

A positive feature of reservoirs in the context of a comprehensive floodland management plan element is their potential for mitigating flooding in several downstream communities in contrast with most other structural floodland management measures which provide only local flood relief. Another favorable aspect of reservoirs is their potential for serving several water resource-related uses—in addition to flood mitigation—such as recreation, low-flow augmentation, and water supply. Negative aspects of reservoirs include the large capital cost, large land area required, potential adverse water quality conditions both within and downstream of the impoundment, and the false sense of security with respect to the flood dangers that may be engendered in downstream reaches leading to the possible influx of urban development into the remaining flood-prone areas.

Diversion: The function of a diversion is to intercept potentially damaging floodwaters at a point upstream of the flood-prone reaches and to route those floodwaters to an acceptable receiving watercourse outside of the subwatershed or watershed in which flood mitigation is desired. Two structural elements are entailed in a diversion alternative: (1) The control structure itself located on the stream channel that establishes the river stage at which the diversion process will begin and the rate at which it will occur; and (2) the open channel or closed conduit that conveys the diverted floodwaters from the stream channel to the point of discharge. A key factor in assessing the application of this alternative to a particular subwatershed or watershed is the availability of a receiving water or other point of discharge outside of the watershed to which the floodwaters may be diverted.

A favorable feature of diversion technique, shared with the reservoir alternative, is the potential which a single major upstream facility may have to mitigate flood problems in several downstream communities. A negative aspect, also shared with impoundments, is the false sense of security with respect to downstream flood dangers that may develop as a result of the construction of a diversion facility.

Another negative feature of diversions for flood control purposes is the potential legal restrictions on the transfer of water between watersheds as discussed in Chapter X, Volume 1, of this report.

Dikes and Floodwalls: Earthen dikes and concrete or sheet steel floodwalls, like those shown on Figure 4, are technically feasible means of providing flood control in certain flood-prone riverine areas. The principal function of dikes and floodwalls is to contain the floodwaters, that is, to prevent the occurrence of overland flow laterally from the channel to adjacent floodland areas containing flood-damage-prone structures and facilities. A key physical factor in the potential application of this structural alternative is the availability of sufficient space between the stream channel and the land uses that are to be protected to permit the construction of the dikes or floodwalls, the latter having the advantage of requiring a narrower strip of land.

In order to be effective in reducing flooding, dikes and floodwalls must normally be supplemented by the installation of backwater gates on those storm sewer outfalls and other drainage outlets penetrating the dikes and floodwalls that have street inlets or other entry points in the area to be protected at elevations approximating the 100-year

Table 18

ALTERNATIVE FLOODLAND MANAGEMENT MEASURES CONSIDERED IN THE MENOMONEE RIVER WATERSHED PLANNING PROGRAM

Alternative: Major Category	Alternative: Name	Function	Comment
Structural	Storage	To detain floodwaters upstream of flood-prone reaches for subsequent gradual release	May be accomplished by on-channel reservoirs or by off-channel or underground storage
	Diversion	To divert waters from a point upstream of the flood-prone reaches and discharge to an acceptable receiving watercourse outside of the watershed	--
	Dikes and floodwalls	To prevent the occurrence of overland flow from the channel to floodland structures and facilities	--
	Channel modification and enclosure	To convey flood flows through a river reach at significantly lower stages	May be accomplished by straightening, lowering, widening, lining, and otherwise modifying a channel or by enclosing a major stream, includes construction of a new length of channel for the purpose of bypassing a reach of a natural stream
	Bridge and culvert alteration or replacement	To reduce the backwater effect of bridges and culverts	May be accomplished by increasing the waterway opening or otherwise substantially altering the crossing or by replacing it
Nonstructural	Reservation of floodlands for recreational and related open space use	To minimize flood damage by using floodlands for compatible recreational and related open space uses and also to retain floodwater storage and conveyance	May be accomplished through private development, such as a golf course, or by public acquisition of the land or of an easement
	Floodland regulations	To control the manner in which new urban development is carried out in the floodlands so as to assure that it does not aggravate upstream and downstream flood problems	May be accomplished through zoning, land subdivision control, sanitary and building ordinances
	Control of land use outside of the floodlands	To control the manner in which urban development occurs outside of the floodlands so as to minimize the hydrologic impact on downstream floodlands	--
	Flood insurance	To minimize monetary loss or reduce monetary impact on structure owner	Premiums may be subsidized or actuarially determined
	Lending institution policies	To discourage acquisition or construction of flood-prone structures by means of mortgage granting procedures	--
	Realtor policies	To discourage acquisition or construction of floodprone structures by providing flood hazard information to prospective buyers	--
	Community utility policies	To discourage construction in flood-prone areas by controlling the extension of utilities and services	--
	Emergency programs	To minimize the danger, damage, and disruption from impending flood events	Such a program may include installation of remote stage sensors and alarms, road closures, and evacuation of residents
	Structure floodproofing	To minimize damage to structures by applying a combination of protective measures and procedures on a structure-by-structure basis	--
	Structure removal	To eliminate damage to existing structures by removing them from flood-prone areas	--

Source: SEWRPC.

recurrence interval river flood stage. A storm water drainage system, which typically includes the aforementioned street storm water inlets and storm sewer outfalls, normally provides for the conveyance of storm water runoff from developed urban areas to the river. During major flood events, however, high river levels can reverse the operation of the storm water drainage system, thus negating its function and resulting in the movement of floodwaters from the river into developed riverine areas, thereby producing unwanted inundation and attendant monetary damages and inconvenience. Backwater gates prevent such flow reversal by functioning as valves that normally pass the storm water to the river but close when the hydraulic head on the river side of the hinged gate exceeds the head on the opposite side of the gate.

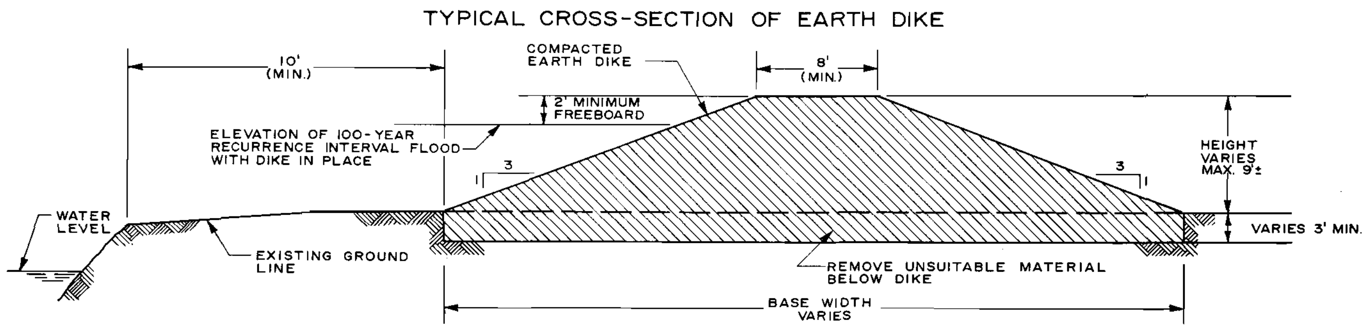
While backwater gates, operating as described above, will prevent the movement of floodwaters from the river, they may, depending on topographic conditions, create local flood problems attributable to the accumulation of storm water runoff which does not have access to the river because of the closed storm sewer outfall. Areas susceptible to this problem can be afforded protection by making provision for temporary or permanent pumping facilities to convey the impounded storm water over the dikes and floodwalls to the river during major flood events.

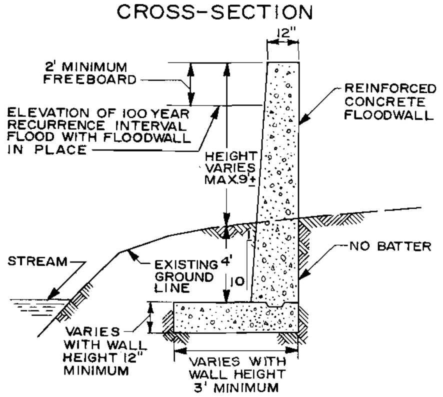
An important factor which must be considered in the design of dikes and floodwalls is the stage which the design flood may be expected to reach in passing through the reach to be protected. This design-condition flood stage may be several feet higher than the "natural" condition stage as a result of the lateral constriction imposed on the stream by the dikes and floodwalls and is used with an appropriate freeboard to establish the crest elevation of the dikes and floodwalls.

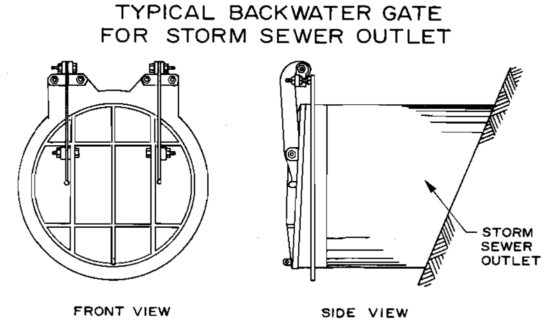
A favorable feature of dikes and floodwalls is that they are a means whereby a given community can readily and by unilateral action protect existing development within its own corporate boundaries. It must be recognized, however, that a serious negative aspect of dikes and floodwalls is their potential for increasing upstream flood stages as a result of the hydraulic constriction imposed on the river and the possibility that a series of successive dike-floodwall projects along a stream could substantially reduce

Figure 4

TYPICAL EARTH DIKE, CONCRETE FLOODWALL, AND BACKWATER GATE







Source: SEWRPC.

the natural floodwater storage capability of the river reach so as to increase downstream discharges and associated stages. Other significant negative characteristics of dikes and floodwalls include the potentially high aesthetic cost, or penalty, normally associated with the placement of these high, long structures in the riverine areas, particularly if those areas are devoted primarily to residential land use, and the false sense of security that may develop with respect to flood dangers through over-topping of the dikes or walls.

Channel Modification and Enclosure: Channel modifications—or channelization, as it is more commonly called—may include one or more of the following major changes to the natural stream channel, all designed to increase the capacity of the stream system channel: straightening and deepening and widening; placement of a concrete invert and partial sidewalls; and reconstruction of selected bridges and culverts 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 in the Menomonee River watershed for a portion of Underwood Creek in the City of Wauwatosa. This form of channel modification is particularly well suited to river reaches containing intense urban development. Upon completion of bypass construction, all or a portion of the original natural channel may be retained to provide for conveyance of local storm water runoff to the relocated channel.

In the context of structural floodland management measures, channel enclosure refers to the installation of large underground conduits along or close to the alignment of major stream reaches intended to convey floodwaters through an area so as to substantially reduce overland flooding and sanitary sewer backup. An example of major channel enclosure in the Menomonee River watershed is the 2.3-mile-long reach of Honey Creek within the Cities of West Allis and Milwaukee in Milwaukee County.

The function of channel modifications or enclosure 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. Key factors in the potential application of this structural floodland management alternative to a flood-prone reach are the acquisition of a strip of land of sufficient width to accommodate the modified channel and careful consideration of the length of upstream and downstream natural channel that must be modified to affect an acceptable transition from the natural channel and floodplain to the channelized or enclosed reach.

A key advantage of channelization or enclosure is that it—like dikes and flood walls—provides a means whereby a community can take unilateral action to effectively provide local relief to a flood-prone area. Significant negative features of major channel modifications or enclosures include the potential high aesthetic cost, particularly of the former, and the possibility for aggravating downstream flood problems through increased downstream discharges and stages resulting from the loss of floodwater storage capacity in a long channelized or enclosed reach.

The Milwaukee-Metropolitan Sewerage Commissions, in cooperation with the Milwaukee County Park Commission, have used major channel modifications to achieve flood control in those riverine areas of Milwaukee County where urbanization has proceeded to the point where channel modifications are, in effect, the only remaining, technically feasible structural means of achieving flood relief. In recent years some major channel modification proposals in Milwaukee County have met with citizen opposition on the grounds that the modifications would destroy, to varying degrees, the beauty and aesthetic quality of the natural riverine environment. A commonly cited example used by such opposition to illustrate the potential negative aesthetic aspects of major channel alterations is the reach of the Kinnickinnic River extending from S. 6th Street to S. 16th Street in the City of Milwaukee. In this reach the natural channel has been replaced by a trapazoidal, concrete lined channel with steep side slopes and has been converted, in effect, to no more than a large open storm drain. In contrast, there are riverine areas in Milwaukee County where major channel modifications have been accomplished while retaining some of the aesthetic attributes of the natural channel and its floodplain. This has generally been achieved by paving only the lower portions of the modified cross-section and then landscaping the remainder of the channel with grass, shrubbery, and trees. The Kinnickinnic River just upstream of the aforementioned reach serves as an example of such channel modification.

Bridge and Culvert Alteration or Replacement: Existing or new highway and railway bridges and culverts, or modifications to existing bridges and culverts, may significantly affect upstream and downstream flood stages and thereby aggravate existing flood problems or create new flood hazards. Furthermore, increased regulatory flood stages are reflected in enlarged floodland regulatory zones, thereby creating difficult administrative, legal, and political problems for community officials. Flood events, on the other hand, can interfere with the proper functioning of the regional transportation system by inundating highways or railroad bridges or their approaches, thereby rendering them impassable during major floods.

The function of the bridge and culvert alteration or replacement alternative is to avoid or minimize the aforementioned adverse effects of existing bridges and culverts on flood flow characteristics and the adverse effects of flood flows on the functioning of the transportation system. Elimination of these adverse effects is accomplished by increasing the size of the waterway opening or by otherwise substantially altering the crossing or by replacing it. The potential usefulness of this structural alternative in a watershed is contingent upon identifying those existing bridges and culverts that produce major backwater effects as a result of their inadequate hydraulic capacity and identifying those structures that are impassable during major flood events. Determination of bridge and culvert backwater effects is a routine procedure associated with the operation of a Hydraulic Submodel 2 as described in Chapter VIII, Volume 1, of this report.

Contemporary bridge design generally employs larger waterway openings that yield relatively small, and in effect insignificant, backwater effects. Therefore, this structural floodland management alternative is most likely to be applicable to older waterway crossings that will be replaced as part of the normal transportation improvement process.

Nonstructural Measures

Each of the 10 nonstructural floodland management measures presented in Table 18 is discussed briefly below. The function of each measure is described and the key factors or basic requirements needed to determine if the given alternative applies to a riverine area or portion of the watershed are discussed. In addition, some of the more significant positive and negative features of the various measures are identified.

Reservation of Floodlands for Recreational and Related Open Space Uses: Comprehensive land use planning recognizes that there is, and will continue to be, a need for active and passive recreational and open space lands readily accessible to residents of the metropolitan area. Floodlands provide an ideal location for such lands and supporting facilities because the floodlands and the environmental corridors of which they are a part provide sufficient space, assure the presence of water and other key recreation elements, improve the accessibility of the recreation areas to the urban population, and are compatible with recreation use and supporting facilities.

Recreational and related open space uses of floodlands may be accomplished by several mechanisms, including public or private acquisition of the land or acquisition of an easement followed by development for recreational use such as a golf course. The principal advantage of this floodland management alternative is its definitiveness and legal incontestability, whereas the key disadvantage of public acquisition of the lands is the public cost. Public acquisition of floodland areas for recreational and related open space use can sometimes be accomplished at no major direct cost to the municipalities by encouraging developers of large tracts of land to dedicate the land and adjacent environmental corridor portions of those tracts to a local government unit or agency for public maintenance and use. Since floodlands are not well suited for residential development not only because of flooding but also because of soils, utility, and other problems; since land subdivision regulations often require developers to provide a minimum amount of recreational and open space land; and since existing floodland regulations may limit the extent of floodland development, the land developer may be receptive to the idea of dedicating the floodlands and adjacent environmental corridors to a local government unit or agency.

In addition to preventing additional flood-prone development, minimizing aggravation of upstream and downstream flood problems, and providing prime and readily accessible outdoor recreational land, the reservation of floodlands for recreational and related open space uses also may be expected to have a significant and favorable impact on the value of residential property in close proximity to the riverine area parkways. A land value study recently was conducted under the regional park and open space planning program[1] of the Commission to investigate the effects of public open space land on residential areas. The emphasis was upon the extent to which residential property values may be influenced by proximity to public open space areas. A variety of information sources and analysis procedures was used to carry out the study, including personal interviews of assessors, appraisers, and developers; collection and collation of census housing value data; analysis of residential housing sales information; analysis of residential land sales information; analysis of locally assessed property values; and a survey of occupants of riverine area residential property.

The study indicates that most public open space lands have a positive impact on the value of residential property situated adjacent to or with a view toward the public open space areas. Furthermore, this impact is directly related to the size of the open land as well as to the value of the natural resource amenities which it contains.

Public open space areas, such as the Menomonee River parkway, that preserve and enhance high value elements of the natural resource base have the greatest impact on the value of adjacent developed residential property. The value of property situated adjacent to or with a view toward such parkways exceeds the value of property located away from the parkway land by an average of about 30 percent. The analysis also revealed that, within a given subdivision that is under development, the sale prices of lots situated adjacent to or with a view toward such parkways exceeds by an average of 12 percent the sale prices of lots situated away from parkway lands.

The land value study also indicated that smaller parks which are intensively developed for active recreation use and which provide only a limited amount of "green" space have little or no positive impact on the value of adjacent residential property. This finding is due to negative factors associated with such locations including: increased traffic and parking problems, noise, rowdyism, and undesirable glare from nighttime lighting of athletic fields. Information presented in the study strongly suggests that a community "benefit-cost" or "revenue-cost" analysis of preserving floodlands for recreational and related open space uses should consider the significant property value enhancement that accrues to properties adjacent to or situated with a view toward riverine area parkways. The same favorable property value condition is true for other large public open space lands that preserve and enhance high value elements of the natural resource base.

Floodland Regulations: Floodland regulations take the form of or are incorporated into zoning, land subdivision, sanitary, and building ordinances adopted by counties, cities, villages, and towns under police powers granted by state legislatures. Such regulations are ordinarily intended for

[1] *SEWRPC Planning Report No. 27, A Regional Park and Open Space Plan for Southeastern Wisconsin, Chapter X, "Impact of Public Open Space Lands on Residential Property Values Based upon an Analysis in Milwaukee County," (to be published in 1977).*

the single purpose of flood damage mitigation by controlling the manner in which new urban development is carried out in the floodlands so as to assure that it is not flood-prone and, equally important, that it does not aggravate upstream and downstream flood problems. As discussed in Chapter X, Volume 1 of this report, the regulation of floodlands in Wisconsin is governed primarily by the rules and regulations adopted by the Wisconsin Department of Natural Resources pursuant to Wisconsin Statutes. All counties, cities, and villages are expected to adopt reasonable and effective floodland regulations under the enabling Wisconsin Statutes. The principal advantage of floodland regulations is that they control the manner in which new development occurs in riverine areas. The principal disadvantage of floodland regulations is that they offer no relief to existing flood-prone structures other than to encourage their ultimate removal from floodland areas.

There is a potential downstream hydrologic problem associated with floodland regulations that employ the two-district floodway-floodplain fringe approach as incorporated in the State of Wisconsin Floodplain Management Program. As described later in this chapter, widespread floodland fill and development can lead to marked increases in downstream flood discharges and stages. The delineation of floodways throughout a watershed and the subsequent filling of the floodplain fringe areas outside of the floodways may, because of the associated reduction in floodland storage capacity, result in significant increases in downstream flood discharges and stages.

Another negative aspect of the two-district floodway-floodplain fringe approach in floodland regulations is that flood stage increases within the community for which a floodway is being determined have the effect of enlarging the area to which floodplain regulations must be applied.[2] This is so because constricting the width of the floodway so as to eliminate from the floodway structures located on its fringe has the effect of increasing the 100-year recurrence interval flood stage, thereby laterally extending the corresponding floodplain boundary and subjecting additional land and structures to floodland regulation.

A third negative feature of the two-district floodway-floodplain fringe approach to floodland regulations is that it may lead to the destruction of the environmental corridors of a watershed since it encourages floodland fill and development outside of the floodway limits, but within environmentally critical areas. There is the possibility of making floodland and other land use recommendations more effective for environmental corridor protection by expanding the regulatory objectives so as to explicitly include corridor protection as well as flood damage mitigation. Such more comprehensive floodland regulations typically incorporate a floodway, a developable floodplain fringe, and an undevelopable conservancy district.

[2] *For a graphic demonstration of this effect, refer to: SEWRPC Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume Two, "Alternative Plans and Recommended Plans," pp. 163 to 172.*

Control of Land Use Outside of the Floodlands: In a watershed it is important to regulate the manner in which urban development occurs outside of the floodlands, as well as within the floodlands, so as to minimize the hydrologic impact on floodland areas receiving direct runoff from tributary watershed areas. Although planning for land use outside of floodland areas has not traditionally been considered a floodland management alternative, the hydrologic hydraulic interdependence between the land surface and the streams of the watershed system suggests that land use planning may indeed be an effective floodland management measure.

The influence of land use on the volume, timing, and peak discharge rate of runoff to the streams of a watershed is discussed and illustrated in Chapter V of Volume 1 of this report. The likely consequences of uncontrolled urban development in the Menomonee River watershed are quantitatively demonstrated later in this Chapter where it is shown that uncontrolled urban development of lands outside of the floodland areas can increase 100-year recurrence interval discharges in the watershed stream system by as much as a factor of six. It is vital, therefore, that land use planning consider the hydrologic-hydraulic consequences of the location of future urban development, the amount of impervious surface in that development, and the manner in which storm water runoff from that new development is controlled.

Federal Flood Insurance: As discussed in Chapter X, Volume 1 of this report, the overriding objective of the National Flood Insurance Program is to encourage the purchase of flood insurance by individual land owners to reduce the need for periodic federal disaster assistance. From the perspective of the owner of the flood-prone residential, commercial, or industrial structure, federal flood insurance provides a means of distributing monetary flood losses in a relatively uniform manner in the form of an annual flood insurance premium and also actually reduces the monetary flood losses in those situations where the insurance premiums are federally subsidized.

It is in the best interest of communities in the Menomonee River watershed to participate in the federal flood insurance program, in accordance with the procedures described in Chapter X, Volume 1 of this report, so as to provide some relief to citizens of those communities in which flood-prone structures are located. It is important to note that one of the requirements that must be met by a community before citizens of that community can participate in the federal flood insurance program is that the community must enact land use controls which meet federal standards for floodland protection and development. A very close tie, therefore, exists between two of the nonstructural floodland measures—the federal flood insurance program and floodland regulations.

Lending Institution Policies: Lending institutions have gradually become more aware of the flood hazards associated with properties located in the floodland areas. The interest of lending institutions in the possible flood-prone status property has been intensified as a result of the Federal Flood Disaster Protection Act of 1973 which expanded the National Flood Insurance Program. This Act requires the purchase of flood insurance for a structure within a flood hazard area when the purchaser seeks a mortgage through a federally supervised lending institution. The private lending institutions in the southeastern Wisconsin area have largely assumed the responsibility for the determination of whether or not a property is in flood-prone area. This information is obtained by the lending institution from the local units of government and the Regional Planning Commission. Indications are that the lending institutions are not reluctant to provide mortgages on flood-prone structures provided that the federal flood insurance is secured by the owner of the property.

Realtor Policies: As a result of an executive order by Governor Patrick Lucey of Wisconsin on November 26, 1973, real estate brokers, salesmen, or their agents are strongly urged to properly inform potential purchasers of property of any flood hazards which may exist at the site. The function of this floodland management measure is to reduce the unwitting acquisition or construction of flood-prone structures by providing flood hazard information to prospective buyers.

Community Utility Policies: Local communities may adopt policies relating to the extension of certain public utility services that discourage construction in flood-prone areas. Such policies should relate to the extension of streets as wells as of such utilities as sanitary sewers and water mains. The location and size or capacity of utility facilities tend to influence the location of urban development. For example, selection of a sewer alignment that parallels and lies close to or within a floodplain or terminates at the edge of a floodplain may, in the absence of other land use controls, result in the construction of flood-prone residential, commercial, and industrial development. The sanitary sewerage system development objectives and standards which have been incorporated into the overall development objectives and standards for the Menomonee River watershed specify that floodlands should not be served by sanitary sewers and that analyses related to the sizing of sanitary sewer system components should not assume the ultimate urbanization of those floodlands. Similar objectives and standards can be established for water supply, transportation, and other facilities and services by the local units of government and other agencies having responsibilities for such services and utilities in the Menomonee River watershed. In addition to contributing to sound floodland management, community utility policies that are restrictive in serving flood-prone areas may have a significant economic benefit in that the unit cost of utilities and services constructed in flood-prone areas is normally higher than the unit cost of such utilities and services constructed in non-flood-prone areas. The incremental costs associated with sanitary sewer construction in flood-prone areas will also include higher treatment cost as the result of potentially increased clear water infiltration and inflow problems that will probably develop in floodlands.

Emergency Programs: The function of an emergency program is to minimize the damage and disruption associated with flooding through a coordinated preplanned series of actions to be taken when a flood is impending or occurring. Such a program may include a variety of devices and techniques such as installation of remote upstream stage sensors and alarms, a siren warning system, preplanned road closures and evacuation of residents, and mobilization of portable pumping equipment to relieve the surcharge of sanitary sewers. In evaluating emergency programs for use in the Menomonee River watershed, it is important to remain cognizant of the "flashy" nature of the watershed's hydrologic-hydraulic system in that, even in the lower reaches of the basin, there may be only several hours of elapsed time between the initial rise of floodwaters and the occurrence of the peak stage.

Structure Floodproofing: As discussed in Chapter VI, Volume 1 of this report, residential, commercial, and industrial structures located within or adjacent to floodlands are particularly vulnerable to flood damage because of the variety of ways by which floodwaters can enter such structures. It is possible and generally practicable for individual owners to make certain structural adjustments to their private properties and to employ certain measures or procedures, all of which are intended to significantly reduce potential flood damages. This approach is referred to as floodproofing, and may be more specifically defined as a combination of structural measures applied to existing structures in combination with selected emergency procedures, all of which are intended to eliminate or significantly reduce damage to the structure and its contents.

Floodproofing measures and techniques intended for application to existing structures generally can be divided into one of two categories: techniques for preventing entry of floodwaters and techniques for insuring continuation of, or at least protection of, utilities and other services during flood events and for protecting structure contents in the event that the water does—by design or otherwise—enter the building. The particular combination of floodproofing measures applied to a given structure must be tailored to the function of the structure, the nature of its construction, and the vertical and horizontal position of the structure within the floodplain. Extensive floodproofing should be applied only under the guidance of a registered professional engineer who has carefully inspected the building and contents, has analyzed its structural integrity, and has evaluated the flood threat. It is important to emphasize that, even if a successful floodproofing program is instituted in a flood-prone area, overland flooding and the inconvenience associated with it will continue to occur.

Prevention of Floodwater Entry: Although a variety of floodproofing measures and techniques is available to prevent the entry of floodwaters, specific measures to a particular structure should be applied only under the guidance of a registered professional engineer. Sanitary sewer backup through basement flood drains may be prevented by installation of backwater valves or the use of vertical standpipes screwed into a fitting in the floor drain provided that the building sewer can withstand the attendant pressure that will be exerted. Sump pumps can remove water that enters the basement of a structure through foundation drains or other openings provided that the discharge point is above and not affected by flood stage. Waterproof seals can be installed at structural joints—

such as the contact between basement walls and the basement floor—and impermeable materials can be applied to the outside of basement walls. Overland flood damage may be prevented by the construction of earthen berms or concrete or masonry walls around the perimeter of the structure or cluster of structures. Glass block[3] may be placed in basement window openings and flood shields have been designed for quick installation over doorways, windows, and other structural openings. Existing structures may be elevated so as to raise their first floors above flood stages.

It is important to reemphasize the critical need for a complete analysis of the ability of a given structure to withstand the external hydrostatic forces that would be applied to the walls and basement floor of a structure prior to implementing floodproofing procedures that are intended to prevent water from entering the basement of such structures. Generally speaking, the concrete block basements widely used in residential construction throughout the Menomonee River watershed are not capable of withstanding hydrostatic forces associated with complete saturation of the soil surrounding the buildings. A realistic alternative, therefore, to attempting to prevent floodwater from entering the basement of such structures is to intentionally flood the basement with clean water prior to the inflow of floodwater thereby maintaining its structural integrity while minimizing the entry of sanitary sewage, sediment, and other objectionable materials normally associated with basement flooding.

Maintaining Utilities and Services: The second category of floodproofing measures applicable to existing residential, commercial, industrial, and other structures consists of techniques designed to insure the maintenance of utilities and other services needed for the building to function possibly during, but certainly immediately after, a flood event. Also included in this category are procedures intended to protect structural contents. Because of the above structural problems, this second category of floodproofing measures should be employed for structures having concrete block basements.

Mechanical equipment such as heating and air conditioning units or manufacturing equipment may be placed on upper floors, elevated above the floor on which it is placed, surrounded by low walls to prevent intrusion of floodwaters, temporarily covered with impermeable sheet material, or altered so as to be mobile for removal from flood-prone areas prior to the occurrence of a flood event. Electrical circuits servicing flood-prone sections of a structure should be altered so that they can be easily shut off, and consideration should be given to moving the electrical service box to the first floor of the structure above anticipated flood levels and to the use of waterproof electrical fixtures in flood-prone areas of the structure. Some mechanical electrical equipment may be protected by removal of critical water-vulnerable components—for example, the blower motor on a heating unit—prior to entry of the floodwaters.

If there is a certainty or high probability water will enter portions of the structure and damage the contents, such as furnishings in a house or stock stored in a commercial building, an emergency evacuation program should be prepared for the contents of the buildings. Flood-vulnerable contents could be temporarily moved out of the buildings or to higher floors or temporarily elevated on supports or shelves.

Some of the above floodproofing measures are contingent upon receiving adequate forewarning—at least several hours—of the impending occurrence of a flood event. It is important to recognize that such a warning, even if it were provided at the outset of a flood, would not be very effective in portions of the Menomonee River watershed since, as discussed in Chapter V of Volume 1 of this report, this relatively small urban basin is characterized as being very "flashy" in its precipitation-runoff characteristics.

Principle Advantages and Disadvantages of Floodproofing: The principal advantage of floodproofing is that it provides a means whereby individual homeowners or property owners unilaterally can take definitive action to protect their flood-prone structures against future flood damage. A significant negative effect of floodproofing is the very real possibility that it will be applied without adequate professional engineering guidance, thereby leading to possible major damage to the structure as well as posing a threat to the owners, tenants, and users of the structure.

Another negative attribute of floodproofing individual structures is the very real possibility that the technique will not be applied in a coordinated way throughout the entire flood-prone portion of a given community, thereby leaving a significant residual demand for flood relief—a demand that will be focused on community officials and will be intensified during and immediately after each flood event. In such a situation and in spite of the fact that numerous individual property owners have implemented floodproofing and have incurred the necessary costs, community officials still will be faced with the problem of reducing the flood threat to those structures that have not been floodproofed.

Structure Removal: Although it is generally technically and economically feasible to floodproof well-constructed brick and masonry structures used for commercial or industrial purposes, it is generally not practicable to floodproof private residences for design flood stages which are above the first floor level. Therefore, the floodproofing measures considered in the design of alternative flood damage abatement plans were supplemented with proposals to remove those residential structures having first floor elevations

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[3] *The Wisconsin Uniform Building Code states that basement windows must have a minimum openable area of 1 percent of the floor area unless ventilation is provided by other means such as mechanical ventilation units. Furthermore, the current policy of the interpretation committee of the Southeastern Wisconsin Building Inspectors Association is to require the use of glass block for basement windows in flood-prone areas and to require that this be supplemented with mechanical ventilation equipment.*

at or below the 100-year recurrence interval flood stage—the stage used to design floodproofing and removal alternatives. Furthermore, it was assumed that it would be technically and economically feasible to floodproof most nonresidential structures within the watershed regardless of the relative position of the first floor elevation with respect to the design flood stage. The cost of removing a residential structure from a flood-prone area was computed as the sum of the structure acquisition cost, structure demolition or moving cost, site restoration costs, and relocation costs, the last of which is provided to the displaced homeowner in compensation for expenses incurred as a result of moving.

A positive aspect of structure removal, in addition to flood damage reduction, is that it enhances the opportunity to develop the aesthetic and recreation potential of riverine lands. Structure removal could assist in restoring river floodlands to an open, near natural state, thereby enhancing the aesthetic value of the riverine area and, in effect, recreating environmental corridors similar to those described and recommended for protection in Chapter III of this volume. Such restored environmental corridor lands could be used for outdoor recreation and related open space purposes.

A negative aspect of structure removal is the opposition which is likely to be encountered from some property owners even if offered an equitable price for the flood damage-prone property. Although some of the value placed on a home may be intangible, and therefore cannot be expressed in monetary terms, it is nevertheless, real and must be considered when structure removal alternatives are proposed.

Another potentially negative aspect of structure removal is a loss in tax base to a community as a result of removing taxable property from within the corporate limits. It should be noted, however, that while there may be a loss in tax base to a community, the net cost to the community may be considerably smaller than the reduced taxes because of the likely compensating effect of several factors including: the reduced cost of municipal services such as water supply, sewerage, and streets; the reduced cost of flood-related emergency services; and the likelihood that some of the evacuated residents will construct new residences within the civil division on previously undeveloped land, thereby adding to the tax base.

HYDROLOGIC-HYDRAULIC CONSEQUENCES OF ALTERNATIVE LAND USE-FLOODLAND DEVELOPMENT CONDITIONS

As noted in Chapter VIII, Volume 1 of this report, the principal purpose of developing and calibrating the water resource simulation model under the Menomonee River watershed study was to provide a tool for quantifying watershed hydrologic, hydraulic, and water quality characteristics under existing conditions as well as under various alternative future development conditions within the watershed. Some of the model output, such as the floodland delineations under existing land uses, is intended for immediate application. Other model output, such as flood flow discharge-frequency relationships for alternative future watershed development conditions, can help in making decisions as to the best form and location of future development. The results of applying the hydrologic and hydraulic submodels to the entire watershed for a number of alternative watershed land use-channel development conditions are described immediately below. Additional model applications to portions of the watershed and its stream system for plan design and evaluation purposes are discussed in a subsequent section of this chapter.

Hydrologic-hydraulic simulation modeling on a watershed-wide basis is intended to quantify the consequences of land use on flood flow characteristics of the Menomonee River watershed. Results of the watershedwide simulation runs demonstrate the potential effectiveness of those nonstructural floodland management measures that determine or influence the use of land in the watershed both within and outside of the floodlands. More specifically, these nonstructural floodland management measures consist of the following three measures identified in Table 18: reservation of floodlands for recreational and related open space land uses, floodland regulations, and control of land use outside of the floodlands.

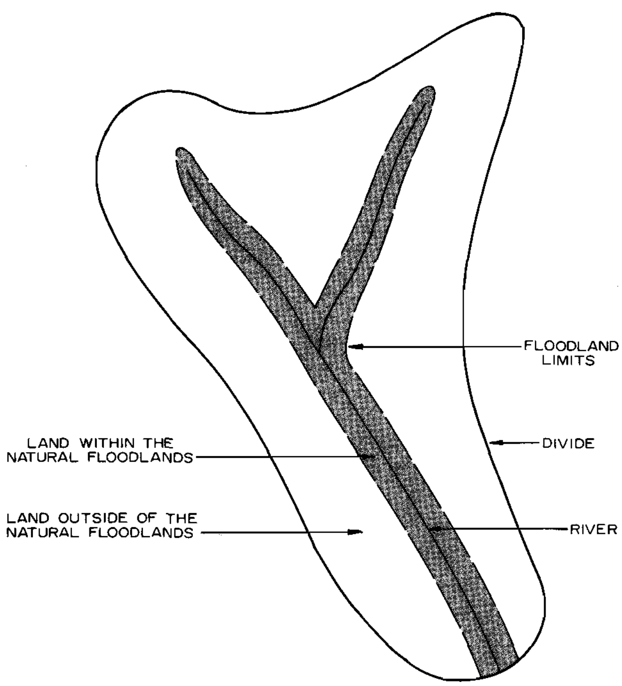
It is important to emphasize that the Water Resource Simulation Model does not reproduce in exact detail the hydrologic-hydraulic behavior of the Menomonee River watershed. However, as described in Chapter VIII, Volume 1 of the report, the simulation modeling approach was determined to be the best practicable tool available to meet the needs of the Menomonee River watershed planning program. Although the results of the modeling may not be as accurate as could be obtained from actual hydrologic and hydraulic monitoring, the results are of sufficient reliability to quantitatively demonstrate the hydrologic-hydraulic consequences of alternative land use and floodland development conditions. It is also important to emphasize that the Water Resource Simulation Model does not make land use decisions but simply provides quantitative information to serve as input into the decisionmaking and planning process.

Procedure

In using the Water Resource Simulation Model to analyze the impact of alternative watershed development conditions, the watershed land surface was envisioned as being portioned into two areas—floodland and nonfloodland. Floodlands were strictly defined as consisting of the river or stream channel plus that portion of the associated floodplain that could be expected to be inundated by a 100-year recurrence interval flood. As shown in plan on Figure 5 and in section on Figure 6, the floodplain of a river or stream is a wide, relatively flat area contiguous with and usually lying on both sides of the channel. The floodplain is bounded on its outer fringes by even higher topography. For purposes of the hydrologic-hydraulic impact analyses described below, floodlands are defined as consisting of the channel plus all of the floodplain between the channel and the topographically higher terrain. With respect to lineal extent, the watershed floodlands were, for the purposes of the hydrologic-hydraulic impact analysis, defined as consisting only of those floodland areas

Figure 5

FLOODLAND AND NONFLOODLAND AREAS OF A WATERSHED



Source: SEWRPC.

associated with the 72 miles of stream selected for hydrologic-hydraulic simulation as described in Chapter V of this volume. Nonfloodland areas were then, by definition, all those portions of the watershed lying outside of the floodlands as defined above.

The watershed land surface was subdivided into floodland and nonfloodland areas for purposes of analyzing the hydrologic-hydraulic impact of urban development because such development has different physical effects in nonfloodland than in floodland areas. Therefore, these physical effects must be modeled differently. A comparison of Case I with Cases II, III, and IV in Figure 6 illustrates how urbanization of lands outside of the floodlands increases the extent of impervious surfaces and thereby produces increased runoff volumes for given rainfall or rainfall-snowmelt events. Furthermore, urban development on nonfloodland areas decreases runoff times, and the net effect of the increased runoff times is a marked increase in flood discharges for a particular rainfall or rainfall-snowmelt event.

In contrast, the principal effect of urban development in the floodlands—whether that development is accomplished by filling to elevate structures above flood stages, as shown by Case III in Figure 6, or by major channelization to reduce flood stages, as illustrated by Case IV in Figure 6—is to reduce the storage capacity of the floodlands and thus the potential for attenuating flood hydrographs as they move through the stream system. A secondary, and additive, effect of floodland development is the reduction in flow resistance due to the more hydraulically efficient channels that normally result and a corresponding decrease in flow times in the stream system. Although the hydrologic-hydraulic effects of urban development within and outside of the floodlands are physically different, and are therefore modeled differently, the effects on instream discharges and stages are additive.

Watershedwide applications of the simulation model were made for seven different floodland and nonfloodland development conditions in order to quantify the probable impact of urban development. The seven development conditions are schematically illustrated in Figure 7 and consist of:

1. Natural Land Use and Floodland Conditions—existing conditions minus the impervious surfaces and floodland modifications, such as placement of fill on the floodplains and construction of major channel works, that have been placed in the watershed as a result of its development by man. Although it was not practicable to determine and then simulate the actual natural or presettlement state of the watershed, an approximate measure of man's impact on the hydrologic-hydraulic regime of the basin may be obtained by determining the effect of removing impervious surfaces and floodland modifications since these are two major means whereby man influences watershed hydrology and hydraulics.

2. Year 1950 Land Use and Floodland Conditions—21 percent urban land use and 79 percent rural land use outside of the floodlands in combination with four miles of major floodland development and modification.

3. Existing (1975) Land Use and Floodland Conditions—54 percent urban land use and 46 percent rural land use outside of the floodlands in combination with 18 miles of major floodland development and modifications.

4. Year 2000 Plan Land Use and Floodland Conditions—65 percent urban land use and 35 percent rural land use outside of the floodlands with no additional floodland development relative to 1975 conditions.

5. Uncontrolled Development of Nonfloodland Areas—complete urbanization of lands outside of the floodlands with no additional floodland development relative to 1975 conditions.[4]

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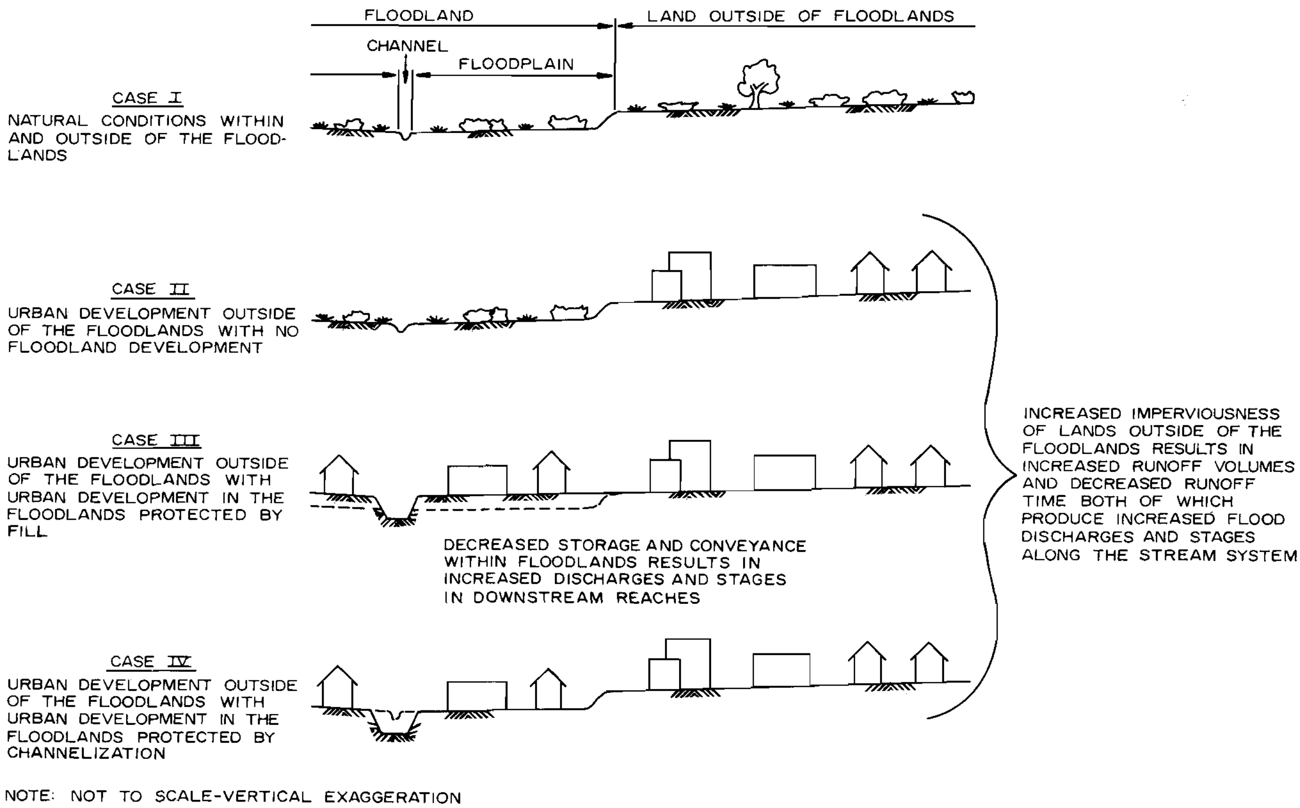
[4]*Simulation of Conditions 5 and 7, each of which assumes complete development of the watershed lands surface, required the development of two hydrologic land segment types described in Chapter VIII, Volume 1 of this report. The additional hydrologic land segment types and associated series of runoff quantities were needed to represent low-density and medium density residential occurring on hydrologic soil Group B in proximity to the Germantown meteorologic station. Conditions of complete urbanization of the watershed land surface postulated the occurrence of low-density and medium density development in combination with hydrologic soil Group B in large areas of the western portion of the Village of Germantown.*

Figure 6

DEVELOPMENT IN FLOODLAND AND NONFLOODLAND AREAS OF A WATERSHED



Source: SEWRPC.

6. Uncontrolled Development of Floodlands—no additional development outside of the floodlands, relative to 1975 conditions, in combination with development of all 72 miles of floodland.

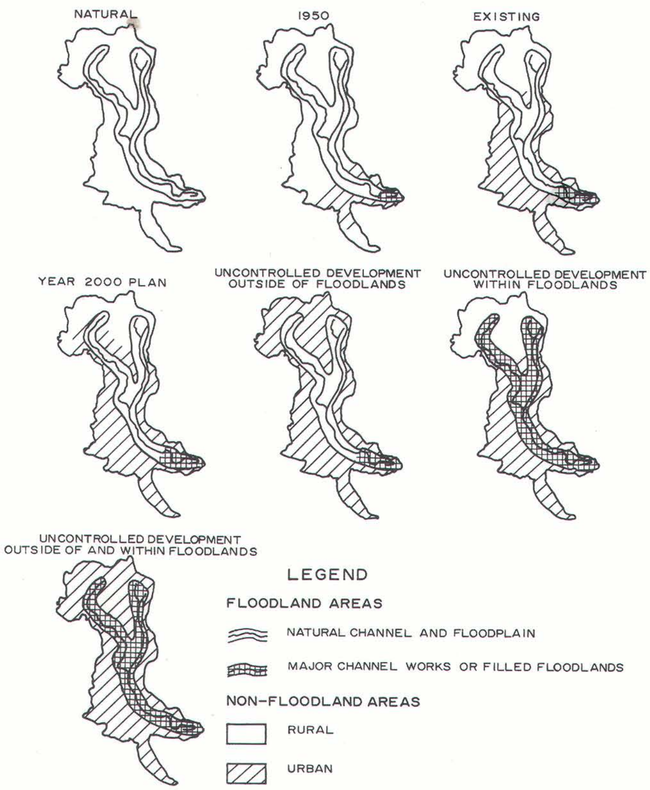
7. Uncontrolled Development of Floodland and Nonfloodland Areas—complete urbanization of lands outside of the floodlands in combination with development of all 72 miles of floodland.

The seven floodland and nonfloodland urbanization configurations were selected to encompass the full spectrum of combinations that have or could exist in the watershed. Therefore, simulation model applications conducted on the seven configurations should yield the corresponding full spectrum of hydrologic-hydraulic impacts of urban development. Although land uses in the watershed will not revert back to natural conditions of condition and are unlikely to change so as to approximate the intense urban development conditions envisioned by Condition 7, modeling of these two extremes, along with intermediate stages, serves to establish the impact of urbanization in the watershed to date and to establish the range within which the future hydrologic-hydraulic regime of the watershed may be expected to lie.

The hydrologic and hydraulic submodels were applied to each of the seven urban configurations using the full available meteorological data base consisting of 35 years of data. Each of these simulation model applications yields corresponding flood flows for the 35-year period for at least 10 selected points in the watershed—six on the Menomonee River, two on the Little Menomonee River, one on Underwood Creek and one on Honey Creek—as shown on Map 9. The 10 locations selected for comparison of flood flows under the seven watershed development conditions were chosen so as to include the Menomonee River and its major tributaries. These sites also were selected to represent locations at which land use transitions exist today—such as on the Menomonee River at the Washington-Waukesha County line—or where such transitions may exist in the future—such as the Ozaukee-Milwaukee County line. The series of flood flows at each of the 10 sites was used to develop log-Pearson Type III discharge-frequency relationships for each selected location. Inasmuch as discharge-frequency relationships are concise representations of a watershed or subwatershed flood flow characteristics, these discharge-frequency relationships were selected as an effective means for comparing and contrasting the hydrologic response of the watershed to the seven combinations of development in floodland and nonfloodland areas.

Figure 7

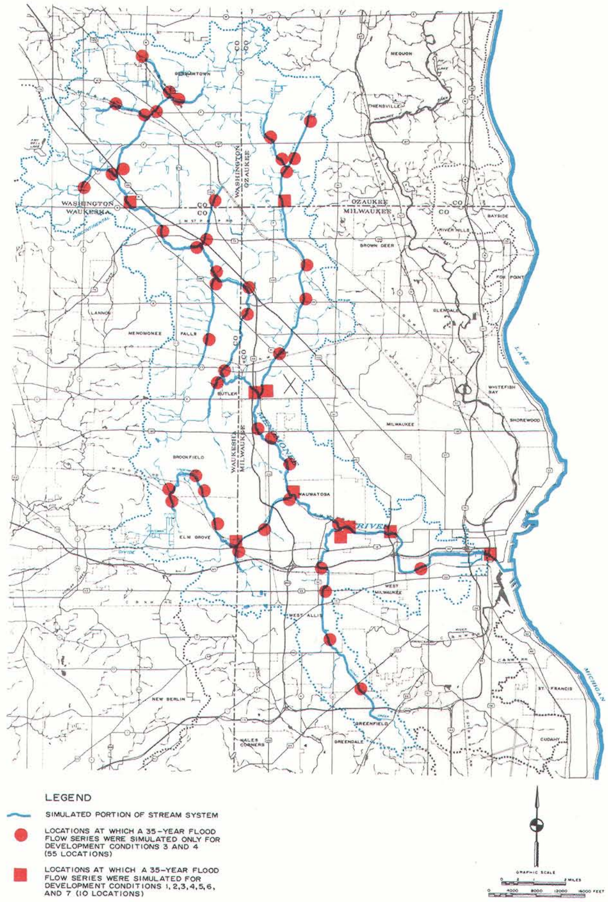
SCHEMATIC REPRESENTATION OF HISTORIC, EXISTING, AND HYPOTHETICAL FUTURE LAND USE AND FLOODLAND DEVELOPMENT CONDITIONS IN THE MENOMONEE RIVER WATERSHED



Source: SEWRPC.

Map 9

LOCATION IN THE MENOMONEE RIVER WATERSHED AT WHICH FLOOD FLOWS WERE DETERMINED WITH THE SIMULATION MODEL



The analysis phase of the watershed planning program included a study of the likely impact of land use and floodland development on flood flows, stages, and damages. The water resource simulation model was applied to each of seven land use-floodland development configurations and flood flow information was then computed at up to 55 locations in the watershed as shown on the map. These flood flows were in turn used to determine corresponding flood stages and average annual flood damages. The studies indicated that complete urbanization of the watershed land surface will have a significant effect on flood flows, stages, and flood damages.

Source: SEWRPC.

The hydraulic response of the watershed to the seven combinations of floodland and nonfloodland development was determined by computing and contrasting the 100-year recurrence interval flood stages in the vicinity of each of the above listed 10 locations for each of the floodland and nonfloodland development conditions. The impact of the various combinations of floodland and nonfloodland development also was quantified by computing and comparing the average annual monetary flood risks for selected flood-prone reaches under the following five development conditions: existing (1975), year 2000 plan, uncontrolled development of nonfloodland areas, uncontrolled development of floodland areas, and uncontrolled development of floodland and nonfloodland areas.

In addition, a much more detailed level of modeling was conducted for the 1975 conditions and year 2000 plan conditions. A 35-year series of flood flows was obtained at a total of 55 points on the watershed stream system as shown on Map 9 for each of these two conditions. The hydraulic submodel then was used to calculate watershed-wide flood stages for each of these conditions, thus facilitating preparation of flood stage profiles and delineation of the corresponding flood hazard areas for 72 miles of stream system in the watershed.

Existing (1975) Land Use and Floodland Conditions

The watershed land surface and stream system were represented as shown on Map 79, Volume 1 of this report, for the purpose of simulating 1975 conditions with the Hydrologic Submodels and Hydraulic Submodel 1. As shown on that map, 11 different land segment types and 108 land segments were required to represent the surface of the watershed outside of the floodland areas. The 72 lineal miles of floodland in the modeled portion of the watershed stream system were represented by 108 stream reaches which are also shown on Map 79, Volume 1 of this report.

Inasmuch as the Hydraulic Submodel 2 also was applied for existing conditions in order to obtain flood stage profiles, the following types of channel data for 1975 conditions were prepared for the 72 miles of stream system: channel floodplain cross-sections at an average spacing of about 500 feet, Manning roughness coefficients (n values) for the channel and each floodplain cross-section, and hydraulic structure—bridge, culvert,and dam—data.

The hydrologic and hydraulic submodel applications yielded a flood flow discharge-frequency relationship at each of 10 locations in the watershed. Table 19 presents 5-, 10-, 25-, 50-, 100-, and 500-year flood flow discharges for each of the 10 selected sites. One hundred year flood flows for each of the seven conditions at each of the 10 selected sites are shown on Map 10. Graphical discharge-frequency relations for four selected locations are presented in Figure 8 to Figure 11. The discharge-frequency relationship for the Menomonee River (River Mile 5.96) near the streamflow gaging station in Wauwatosa is shown in Figure 8, whereas Figure 9 shows the discharge-frequency relationship for the Menomonee River at the Washington-Waukesha County line (River Mile 23.47), Figure 10 shows the discharge-frequency relationship for the Little Menomonee River at the Ozaukee-Milwaukee County line (river mile 6.95); and Figure 11 shows the discharge-frequency relationship for Underwood Creek at the Waukesha-Milwaukee County line (River Mile 2.53).

The 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval discharges were used to generate flood stages for 72 miles of the watershed stream system with the computed stages being obtained at an average spacing of 500 feet. The resulting 100-year recurrence interval flood stages in the vicinity of the 10 locations in the basin are set forth in Table 20.

The 5-, 10-, 25-, 50-, and 100-year recurrence interval discharges for the Menomonee River at Wauwatosa under existing (1975) land use and channel conditions are set forth in Table 21. These discharge values are based on a statistical analysis of the 35-year series of simulated flood flows. Comparable flows obtained by a statistical analysis of 12 years of historic flood flows at that location as reported in Chapter V, Volume 1, of this report, also are set forth in Table 21. It is important to note that the discharge-frequency analyses of 35 years of simulated flood flows incorporate the 12 years of historic flood flows inasmuch as the historic flows were used to calibrate the Water Resource Simulation Model prior to initiating the production runs that resulted in the development of the 35-year series. For a given recurrence interval, the flood discharge based on a statistical analysis of 35 years of data is generally less than the flood flow based on the 12 years of data. This is consistent with research results, as reported in Chapter V, Volume 1, of this report, which indicate that short periods of record tend to result in overestimation, rather than underestimation, of peak flood flow discharges for specified recurrence intervals. It is of interest to note that the existing condition 100-year discharge of 13,500 cfs for the Menomonee River at Wauwatosa equals flood of record at that location, that is, the 13,500 cfs flood flow recorded there on April 21, 1973.

"Natural" Land Use and Floodland Conditions

Natural conditions are defined as the existing conditions in the watershed minus all of the impervious surfaces and the floodland modifications that have developed in the watershed as a result of man's activities. The watershed land surface and stream channel system were represented as shown on the Map 11, four different land segment types and 39 land segments being required to represent the surface of the watershed outside of the floodland areas. The 72 lineal miles of floodland in the modeled portion of the watershed stream system were represented by 39 stream reaches as shown on Map 11.

Application of the hydrologic and hydraulic simulation model using 35 years of meteorological data yielded flood flow discharge-frequency relationships for each of the 10 selected locations in the basin. Table 19 sets forth the 5-, 10-, 25-, 50-, 100-, and 500-year flood flow discharges for each of the 10 sites. Supplemental computations yielded 100-year recurrence interval flood stages at each of the 10 locations in the basin as set forth in Table 20. Graphical discharge-frequency relationships for four selected locations are presented in Figure 8 to Figure 11.

Year 1950 Land Use and Floodland Conditions

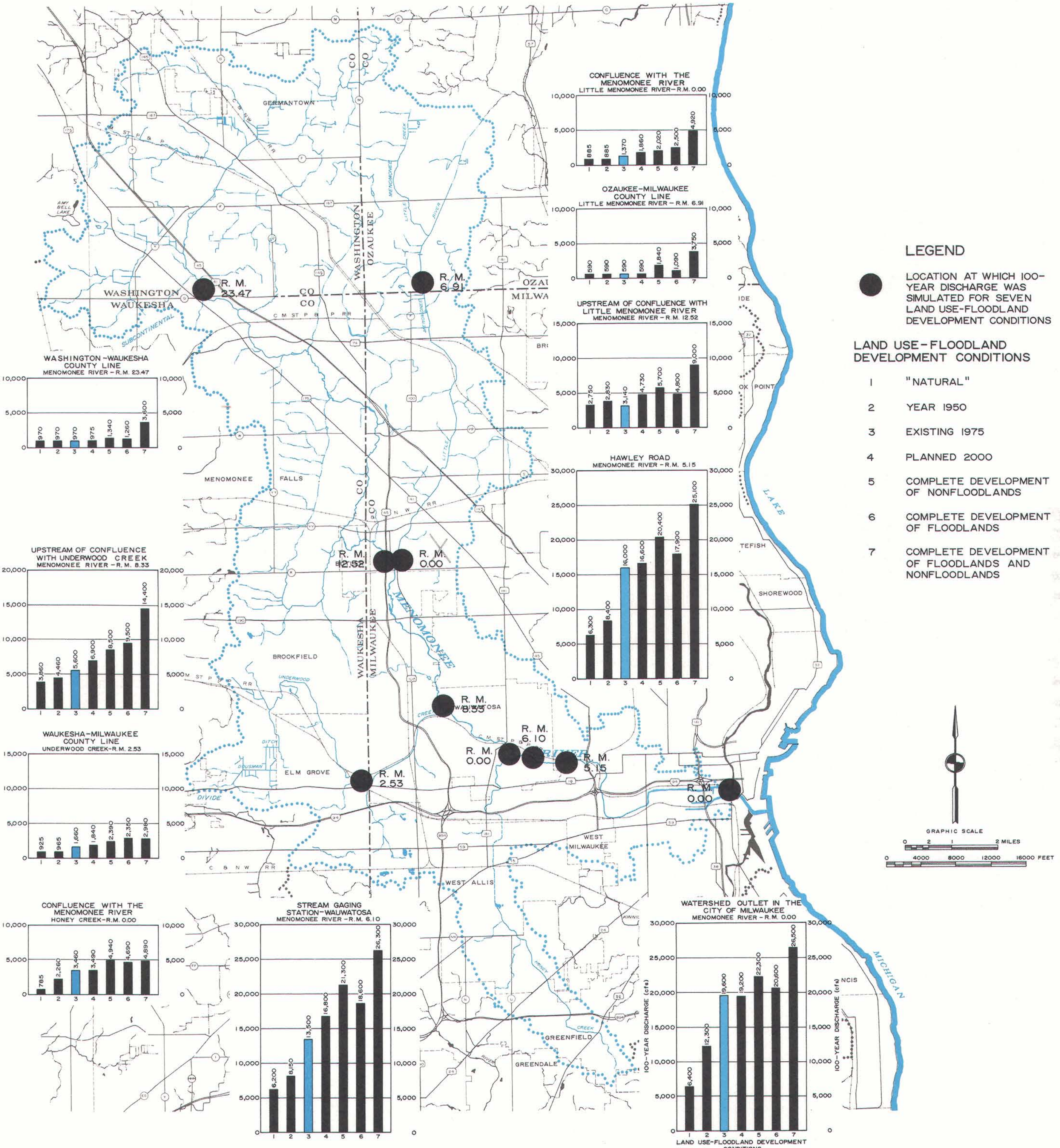
This point in time was selected for simulation because it marked the beginning of an approximately two-decade-long period of rapid population growth and of an even more rapid conversion of land from rural to urban use within the Menomonee River watershed. In the 20-year period from 1950 to 1970, a 42 percent increase in the population of the watershed was accompanied by a 156 percent increase in the amount of land devoted to urban use within the watershed and by marked decrease in the overall density of the developed portions of the watershed from 8,400 persons per square mile to about 4,800 persons per square mile. A comparison of the 1950-conditions flood flow characteristics of the watershed to the 1975-conditions flood flow characteristics thus provides a good illustration of some of the environmental consequences of areawide urban development.

The watershed land surface and stream system were represented as shown on Map 12 for the purpose of simulating 1950 conditions with the Hydrologic Submodel and Hydraulic Submodel 1. As shown on the map, nine different land segment types and 39 land segments were required to represent the surface of the watershed outside of the floodland areas. The 72 lineal miles of floodland in the modeled portion of the watershed stream system were represented by 39 stream reaches which are shown on Map 12.

Application of the hydrologic and hydraulic simulation model using 35 years of meteorological data, yielded flood flow discharge-frequency relationships for each of the 10 selected locations in the basin. Table 19 presents the 5-, 10-, 25-, 50-, 100-, and 500-year flood flow discharge for each of the 10 sites. Supplemental computation yielded 100-year recurrence interval flood stages at each of the 10 locations in the basin as set forth in Table 20. Graphical discharge-frequency relationships for four selected locations are presented in Figure 8 to Figure 11.

Map 10

THE EFFECTS OF URBANIZATION ON 100-YEAR FLOOD FLOWS IN THE MENOMONEE RIVER WATERSHED



The extent to which the floodland areas of a watershed are filled and developed and the degree to which areas outside of the floodlands are urbanized can have a marked impact on flood flows. Analyses conducted under the watershed study indicate that, relative to existing conditions, 100-year flood flows in the watershed under conditions of complete development of floodland and nonfloodland areas may be expected to increase from 40 to 540 percent.

Source: SEWRPC.

Table 19

HYDROLOGIC EFFECT OF SELECTED LAND USE-FLOODLAND DEVELOPMENT CONDITIONS IN THE MENOMONEE RIVER WATERSHED

Location				Condition 1: Natural[a]		Condition 2: 1950			Condition 3: 1975		Condition 4: 2000 Plan			Condition 5: Uncontrolled Development Outside of Floodlands			Condition 6: Uncontrolled Development Within Floodlands			Condition 7: Uncontrolled Development Within and Outside of Floodlands		
Stream	River Mile	Description	Recurrence Interval (Years)	Discharge (cfs)	Relative to 1975 Conditions (Ratio)	Discharge (cfs)	Relative to Natural Conditions (Ratio)	Relative to 1975 Conditions (Ratio)	Discharge (cfs)	Relative to Natural Conditions (Ratio)	Discharge (cfs)	Relative to Natural Conditions (Ratio)	Relative to 1975 Conditions (Ratio)	Discharge (cfs)	Relative to Natural Conditions (Ratio)	Relative to 1975 Conditions (Ratio)	Discharge (cfs)	Relative to Natural Conditions (Ratio)	Relative to 1975 Conditions (Ratio)	Discharge (cfs)	Relative to Natural Conditions (Ratio)	Relative to 1975 Conditions (Ratio)
Menomonee River	0.00	Watershed Outlet in the City of Milwaukee	5	3,060	0.4	5,250	1.7	0.7	8,050	2.6	8,800	2.9	1.1	10,300	3.4	1.3	8,100	2.6	1.0	11,500	3.8	1.4
			10	3,930	0.4	6,600	1.7	0.6	10,300	2.6	10,900	2.8	1.1	12,700	3.2	1.2	10,400	2.6	1.0	14,500	3.7	1.4
			25	4,980	0.4	8,600	1.7	0.6	13,500	2.7	13,900	2.8	1.0	16,200	3.3	1.2	13,900	2.8	1.0	18,800	3.8	1.4
			50	5,700	0.3	10,300	1.8	0.6	16,400	2.9	16,400	2.9	1.0	19,100	3.4	1.2	17,000	3.0	1.0	22,500	3.9	1.4
			100	6,400	0.3	12,300	1.9	0.6	19,600	3.1	19,200	3.0	1.0	22,300	3.5	1.1	20,600	3.2	1.1	26,500	4.1	1.4
			500	7,800	0.3	17,700	2.3	0.6	29,000	3.7	26,800	3.4	0.9	30,900	4.0	1.1	31,200	4.0	1.1	37,700	4.8	1.3
Menomonee River	4.23	Chicago, Milwaukee, St. Paul, and Pacific Railroad	5	2,850	0.4	2,940	1.0	0.5	6,350	2.2	7,300	2.5	1.1	9,000	3.2	1.4	6,550	2.3	1.0	10,300	3.6	1.6
			10	3,700	0.4	3,870	1.0	0.5	8,150	2.2	9,100	2.5	1.1	11,300	3.1	1.4	8,550	2.3	1.0	13,100	3.5	1.6
			25	4,780	0.4	5,350	1.1	0.5	10,900	2.3	11.800	2.5	1.1	14,600	3.1	1.3	11,700	2.4	1.1	17,300	3.6	1.6
			50	5,550	0.4	6,750	1.2	0.5	13,300	2.4	14,100	2.5	1.1	17,300	3.1	1.3	14,500	2.6	1.1	21,000	3.8	1.6
			100	6,300	0.4	8,400	1.3	0.5	16,000	2.5	16,600	2.6	1.0	20,400	3.2	1.3	17,900	2.8	1.1	25,100	4.0	1.6
			500	8,000	0.3	13,600	1.7	0.6	24,200	3.0	23,900	3.0	1.0	29,100	3.6	1.2	28,300	3.5	1.2	37,100	4.6	1.5
Menomonee River	6.10	Streamflow Gaging Station in the City of Wauwatosa	5	2,770	0.5	2,780	1.0	0.5	5,800	2.1	7,300	2.6	1.3	9,150	3.3	1.6	6,400	2.3	1.1	10,500	3.8	1.8
			10	3,600	0.5	3,680	1.0	0.5	6,900	1.9	9,100	2.5	1.3	11,500	3.2	1.7	8,450	2.3	1.2	13,500	3.8	2.0
			25	4,670	0.5	5,150	1.1	0.6	9,200	2.0	11,800	2.5	1.3	15,000	3.2	1.6	11,800	2.5	1.3	17,900	3.8	1.9
			50	5,450	0.5	6,500	1.2	0.6	11,200	2.1	14,100	2.6	1.3	17,000	3.3	1.6	14,900	2.7	1.3	21,900	4.0	2.0
			100	6,200	0.5	8,150	1.3	0.6	13,500	2.2	16,800	2.7	1.2	21,300	3.4	1.6	18,600	3.0	1.4	26,300	4.2	1.9
			500	7,900	0.4	13,300	1.7	0.7	20,400	2.6	24,300	3.1	1.2	30,600	3.9	1.5	30,300	3.8	1.5	39,100	4.9	1.9
Menomonee River	8.33	Immediately Upstream of the Confluence with Underwood Creek in the City of Wauwatosa	5	1,690	0.7	1,820	1.1	0.7	2,580	1.5	3,490	2.0	1.3	4,380	2.6	1.7	3,450	2.0	1.3	6,850	4.1	2.7
			10	2,200	0.7	2,340	1.1	0.7	3,220	1.5	4,230	1.9	1.3	5,300	2.4	1.6	4,530	2.1	1.4	8,500	3.9	2.6
			25	2,850	0.7	3,100	1.1	0.8	4,110	1.4	5,250	1.8	1.3	6,500	2.3	1.6	6,200	2.2	1.5	10,800	3.8	2.6
			50	3,360	0.7	3,740	1.1	0.8	4,830	1.4	6,050	1.8	1.3	7,450	2.2	1.5	7,750	2.3	1.6	12,500	3.7	2.6
			100	3,860	0.7	4,460	1.2	0.8	5,600	1.5	6,900	1.8	1.2	8,500	2.2	1.5	9,500	2.5	1.7	14,400	3.7	2.6
			500	5,050	0.7	6,450	1.3	0.8	7,700	1.5	9,100	1.8	1.2	11,100	2.2	1.4	14,900	3.0	1.9	19,100	3.8	2.5
Menomonee River	12.52	Immediately Upstream of the Confluence with the Little Menomonee River in the City of Milwaukee	5	1,060	0.8	1,070	1.0	0.8	1,280	1.2	2,300	1.9	1.6	2,630	2.5	2.1	1,630	1.5	1.3	4,000	3.8	3.1
			10	1,410	0.8	1,430	1.0	0.9	1,660	1.2	2,830	2.0	1.7	3,260	2.3	2.0	2,190	1.6	1.3	5,050	3.6	3.0
			25	1,910	0.9	1,940	1.0	0.9	2,200	1.2	3,550	1.9	1.6	4,150	2.2	1.9	3,080	1.6	1.4	6,500	3.4	3.0
			50	2,310	0.9	2,370	1.0	0.9	2,650	1.1	4,130	1.8	1.6	4,890	2.1	1.8	3,870	1.7	1.5	7,700	3.3	2.9
			100	2,750	0.9	2,830	1.0	0.9	3,140	1.1	4,730	1.7	1.5	5,700	2.1	1.8	4,800	1.7	1.5	9,000	3.3	2.9
			500	3,890	0.9	4,090	1.1	0.9	4,500	1.2	6,300	1.6	1.4	7,850	2.0	1.7	7,560	1.9	1.7	12,400	3.2	2.8
Menomonee River	23.47	Washington-Waukesha County Line	5	365	0.8	365	1.0	0.8	430	1.2	560	1.5	1.3	755	2.1	1.8	520	1.4	1.2	1,750	4.8	4.1
			10	480	0.9	480	1.0	0.9	525	1.1	665	1.4	1.3	890	1.9	1.7	680	1.4	1.3	2,150	4.5	4.1
			25	655	1.0	655	1.0	1.0	675	1.0	790	1.2	1.2	1,070	1.6	1.6	900	1.4	1.3	2,700	4.1	4.0
			50	805	1.0	805	1.0	1.0	805	1.0	830	1.0	1.0	1,200	1.5	1.5	1,080	1.3	1.3	3,140	3.9	3.9
			100	970	1.0	970	1.0	1.0	970	1.0	975	1.0	1.0	1,340	1.4	1.4	1,260	1.3	1.3	3,600	3.7	3.7
			500	1,440	1.0	1,440	1.0	1.0	1,440	1.0	1,440	1.0	1.0	1,680	1.2	1.2	1,730	1.2	1.2	4,800	3.3	3.3

Table 19 (continued)

Part II

Table 19 (continued)

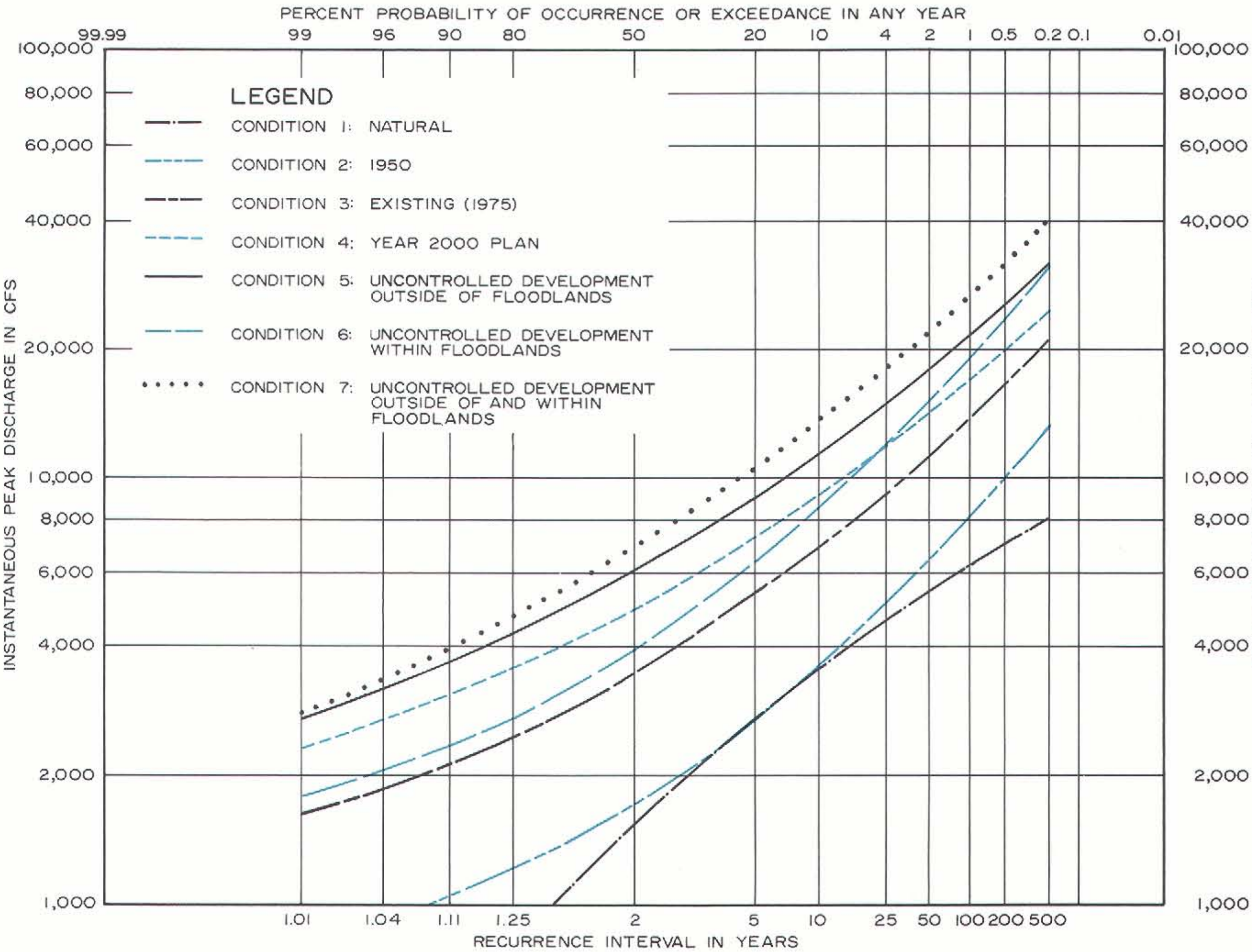
Stream	River Mile	Description	Recurrence Interval (Years)	Condition 1: Natural[a] Discharge (cfs)	Condition 1: Relative to 1975 Conditions (Ratio)	Condition 2: 1950 Discharge (cfs)	Condition 2: Relative to Natural Conditions (Ratio)	Condition 2: Relative to 1975 Conditions (Ratio)	Condition 3: 1975 Discharge (cfs)	Condition 3: Relative to Natural Conditions (Ratio)	Condition 4: 2000 Plan Discharge (cfs)	Condition 4: Relative to Natural Conditions (Ratio)	Condition 4: Relative to 1975 Conditions (Ratio)	Condition 5: Uncontrolled Development Outside of Floodlands Discharge (cfs)	Condition 5: Relative to Natural Conditions (Ratio)	Condition 5: Relative to 1975 Conditions (Ratio)	Condition 6: Uncontrolled Development Within Floodlands Discharge (cfs)	Condition 6: Relative to Natural Conditions (Ratio)	Condition 6: Relative to 1975 Conditions (Ratio)	Condition 7: Uncontrolled Development Within and Outside of Floodlands Discharge (cfs)	Condition 7: Relative to Natural Conditions (Ratio)	Condition 7: Relative to 1975 Conditions (Ratio)
Little Menomonee River	0.00	At the Confluence	5	425	0.6	430	1.0	0.7	655	1.5	955	2.2	1.5	950	2.2	1.5	875	2.1	1.3	2,290	5.4	3.5
		with the	10	540	0.7	540	1.0	0.7	800	1.5	1,150	2.1	1.4	1,125	2.1	1.4	1,160	2.1	1.5	2,850	5.3	3.6
		Menomonee River in	25	680	0.7	680	1.0	0.7	1,010	1.5	1,410	2.1	1.4	1,370	2.0	1.4	1,610	2.4	1.6	3,630	5.3	3.6
		the City of Milwaukee	50	785	0.7	785	1.0	0.6	1,180	1.5	1,630	2.1	1.4	1,790	2.3	1.5	2,020	2.6	1.7	4,260	5.4	3.6
			100	885	0.6	885	1.0	0.6	1,370	1.5	1,860	2.1	1.4	2,020	2.3	1.5	2,500	2.8	1.8	4,920	5.6	3.6
			500	1,100	0.6	1,100	1.0	0.6	1,870	1.7	2,480	2.3	1.3	2,360	2.1	1.3	3,940	3.6	2.1	6,650	6.0	3.6
Little Menomonee River	6.91	Ozaukee-Milwaukee	5	265	1.0	265	1.0	1.0	265	1.0	265	1.0	1.0	945	3.6	3.6	345	1.3	1.3	1,720	6.5	6.6
		County Line	10	340	1.0	340	1.0	1.0	340	1.0	340	1.0	1.0	1,140	3.4	3.4	485	1.4	1.4	2,150	6.3	6.3
			25	440	1.0	440	1.0	1.0	440	1.0	440	1.0	1.0	1,400	3.2	3.2	695	1.6	1.6	2,740	6.2	6.2
			50	515	1.0	515	1.0	1.0	515	1.0	515	1.0	1.0	1,610	3.1	3.1	880	1.7	1.7	3,230	6.3	6.3
			100	590	1.0	590	1.0	1.0	590	1.0	590	1.0	1.0	1,840	3.1	3.1	1,090	1.8	1.8	3,750	6.4	6.4
			500	775	1.0	775	1.0	1.0	775	1.0	775	1.0	1.0	2,420	3.1	3.1	1,680	2.2	2.2	5,100	6.6	6.6
Underwood Creek	2.53	Waukesha-Milwaukee	5	350	0.6	365	1.0	0.6	580	1.7	640	1.8	1.1	835	2.4	1.4	625	1.8	1.1	905	2.6	1.6
		County Line Imme-	10	475	0.7	500	1.1	0.7	725	1.5	845	1.8	1.2	1,110	2.3	1.5	880	1.9	1.2	1,240	2.6	1.7
		diately Upstream of	25	650	0.6	685	1.1	0.7	1,030	1.6	1,170	1.8	1.1	1,540	2.4	1.5	1,320	2.0	1.3	1,790	2.8	1.7
		Confluence with the	50	785	0.6	820	1.0	0.6	1,310	1.7	1,480	1.9	1.1	1,930	2.5	1.5	1,770	2.3	1.4	2,320	3.0	1.8
		South Branch of	100	925	0.6	965	1.0	0.6	1,660	1.8	1,840	2.0	1.1	2,390	2.6	1.4	2,350	2.5	1.4	2,980	3.2	1.8
		Underwood Creek	500	1,260	0.5	1,300	1.0	0.5	2,760	2.2	2,980	2.4	1.1	3,820	3.0	1.4	4,370	3.5	1.6	5,150	4.1	1.9
Honey Creek	0.00	At the Confluence	5	355	0.2	875	2.5	0.5	1,750	4.9	2,090	5.9	1.2	2,410	6.8	1.4	1,870	5.3	1.1	2,350	6.6	1.3
		with the	10	465	0.2	1,120	2.4	0.5	2,140	4.6	2,460	5.3	1.1	1,960	6.4	1.4	2,390	5.1	1.1	2,890	6.2	1.4
		Menomonee River in	25	600	0.2	1,510	2.5	0.6	2,640	4.1	2,890	4.8	1.1	3,710	6.2	1.4	3,190	5.3	1.2	3,630	6.1	1.4
		the City of Wauwatosa	50	695	0.2	1,850	2.7	0.6	3,040	4.4	3,190	4.6	1.0	4,310	6.2	1.4	3,890	5.6	1.3	4,240	6.1	1.4
			100	785	0.2	2,260	2.9	0.7	3,460	4.4	3,490	4.4	1.0	4,940	6.3	1.4	4,690	6.0	1.4	4,890	6.2	1.4
			500	975	0.2	3,470	3.6	0.8	4,520	4.6	4,170	4.3	0.9	6,550	6.7	1.4	7,050	7.2	1.6	6,600	6.8	1.5
		Maximum Ratio of 10-Year Discharges			1.0		2.4	1.0		4.6		5.3	1.7		6.4	3.4		5.1	1.5		6.3	6.3
		Minimum Ration of 10-Year Discharges			0.2		1.0	0.5		1.0		1.0	1.0		1.9	1.2		1.4	1.0		2.6	1.4
		Median Ratio of 10-Year Discharges			0.7		1.0	0.7		1.5		2.0	1.2		2.4	1.5		2.1	1.2		3.8	2.0
		Maximum Ratio of 100-Year Discharges			1.0		2.9	1.0		4.4		4.4	1.5		6.3	3.1		6.0	1.9		6.4	6.4
		Minimum Ratio of 100-Year Discharges			0.2		1.0	0.5		1.0		1.0	1.0		1.4	1.1		1.3	1.1		3.2	1.4
		Median Ratio of 100-Year Discharges			0.6		1.0	0.6		1.5		2.0	1.1		2.6	1.5		2.5	1.4		4.0	1.9

[a] *Existing (1975) conditions minus all impervious surfaces and channel modifications.*

Source: SEWRPC.

Figure 8

SIMULATED DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE MENOMONEE RIVER AT WAUWATOSA (RIVER MILE 6.10) UNDER HISTORIC, EXISTING, AND FUTURE CONDITIONS



Source: SEWRPC.

<u>Year 2000 Plan Land Use and Floodland Conditions</u>

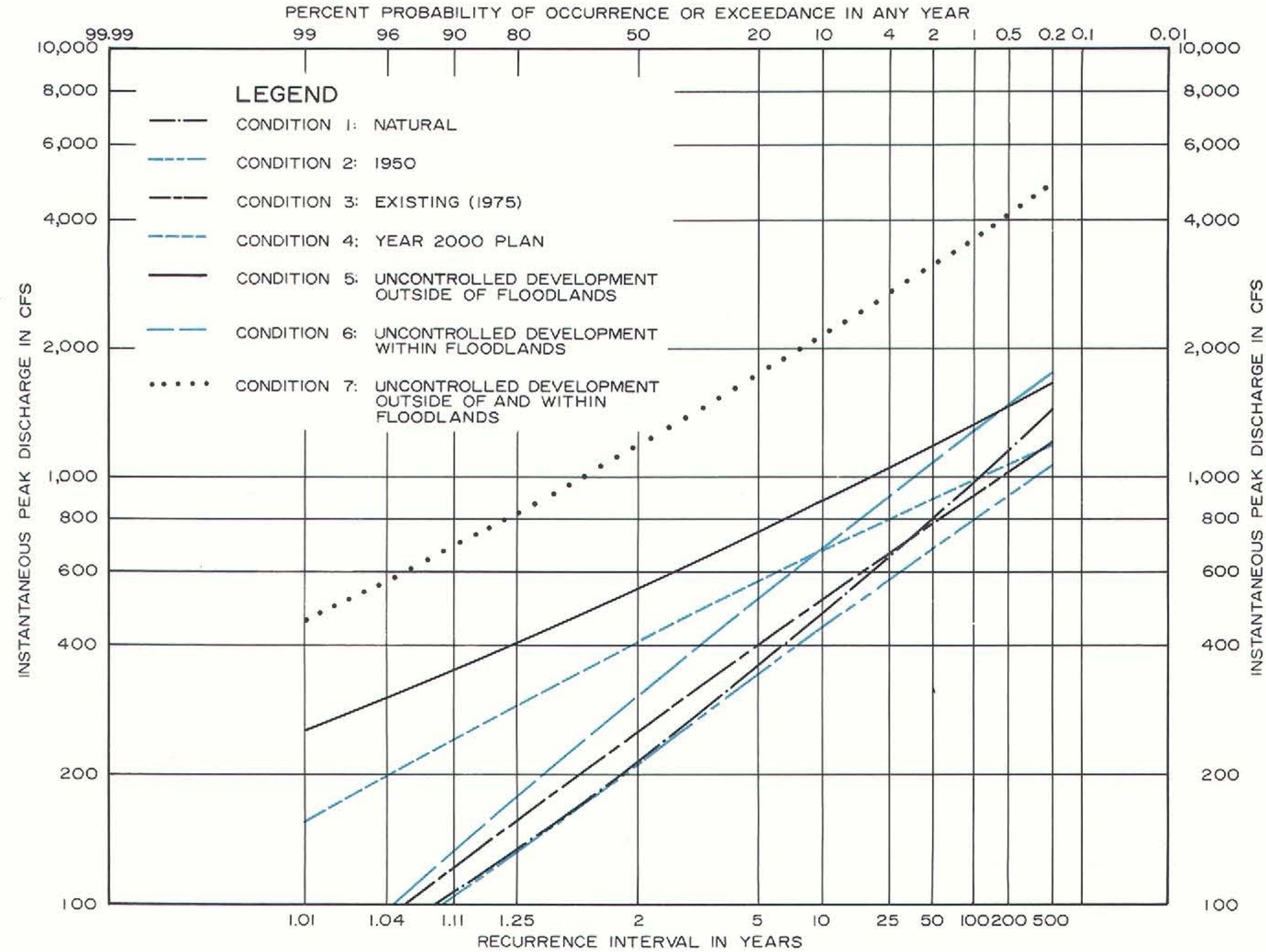
The recommended year 2000 land use plan for the Menomonee River watershed is described in Chapter III of this volume. That plan calls for accommodating the forecast 12 percent increase in population in the watershed by the conversion of about 15 square miles of land from rural to urban use by the year 2000. The planned conversion of land from rural to urban use will produce changes in the flood flow characteristics of the watershed. The year 2000 plan condition simulation was intended to quantify these changes in flood flow characteristics in order to determine where within the watershed changes may be expected, the magnitude of the changes, and the possible significance of the changes with respect to the aggravation of existing flood problems or to the development of new flood problems.

The watershed land surface and stream system were represented as shown on Map 13 for the purpose of simulating the hydrologic and hydraulic behavior of the watershed under the year 2000 planned land use and floodland conditions. As shown on the map, 11 different land segment types and 108 land segments were required to represent the surface of the watershed outside of the floodland areas. The 72 lineal miles of floodland in the modeled portion of the watershed stream system were represented by 108 stream reaches which are shown on Map 13.

Application of the hydrologic and hydraulic simulation model using 35 years of meteorological data, yielded flood flow discharge-frequency relationships for each of the 10 selected locations in the basin. Table 19 presents the 5-, 10-, 25-, 50-, 100-, and 500-year flood flow discharges for each of the 10 sites. Supplemental computations yielded 100-year recurrence interval flood stages at each of 10 locations in the basin as set forth in Table 20. Graphical discharge-frequency relationships for four selective locations are presented in Figure 8 to Figure 11.

Figure 9

SIMULATED DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE MENOMONEE RIVER AT THE WASHINGTON-WAUKESHA COUNTY LINE (RIVER MILE 23.47) UNDER HISTORIC, EXISTING, AND FUTURE CONDITIONS



Source: SEWRPC.

The hydrologic-hydraulic summary tables which appear in Appendix E of this volume contain 10-, 50-, and 100-year recurrence interval flood discharges and stages for the 72 miles of watershed stream system included in the simulation analysis. The corresponding flood stage profiles and flood hazard maps appear in Appendix D of this volume.

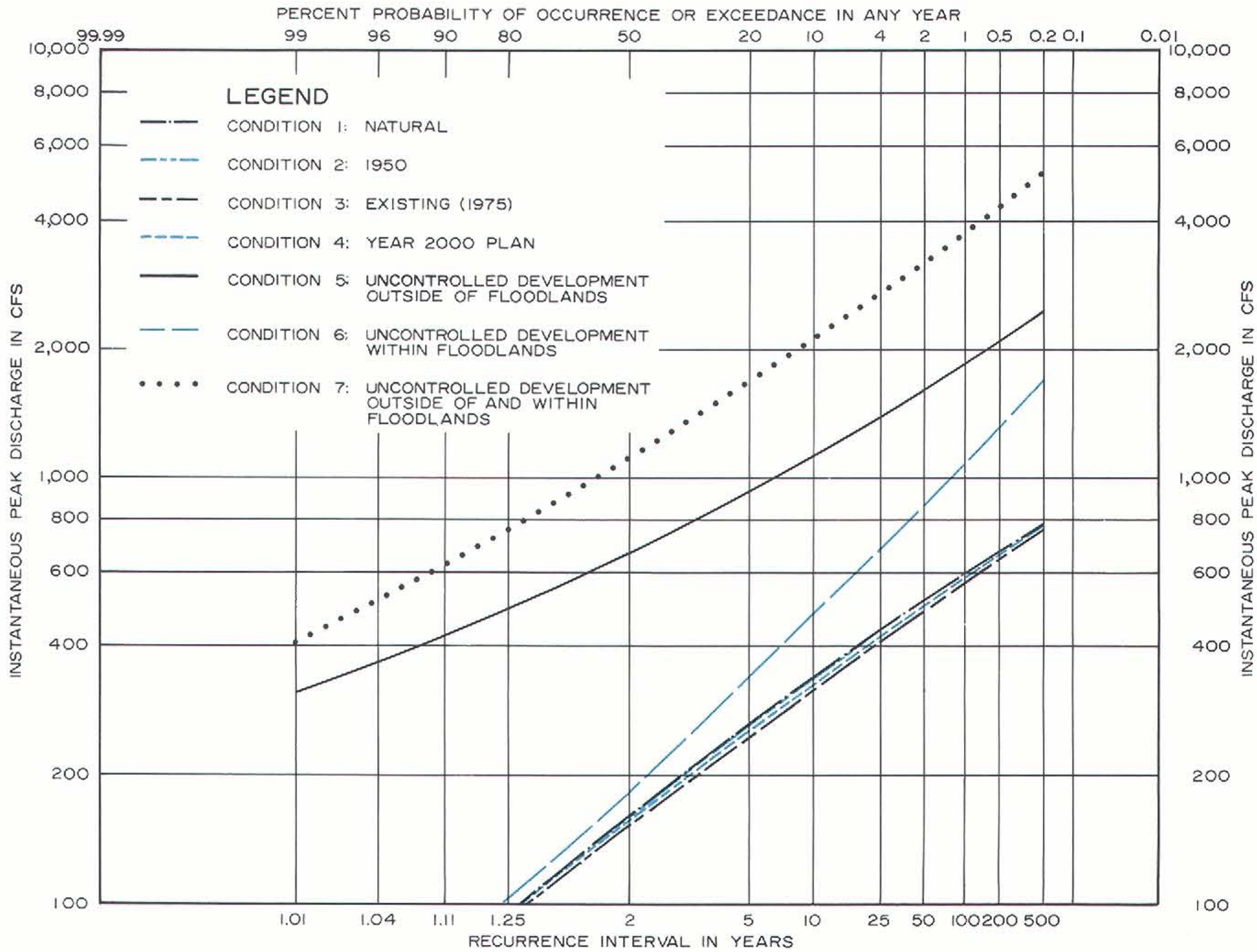
Uncontrolled Development Outside of Floodlands

As already noted, Condition 5 assumes complete urbanization of the watershed land surface outside of the floodlands with no additional development or fill in the floodland areas. The watershed land surface and stream system were represented as shown on Map 14 for the purpose of simulating the hydrologic and hydraulic behavior of the watershed under Condition 5. As shown on the map, eleven different land segments types and 39 land segments were required to represent the surface of the watershed outside of the floodland areas. The 72 miles of floodland in the modeled portion of the watershed stream systems were represented exactly as were they for 1975 conditions and year 2000 plan conditions.

Application of the hydrologic and hydraulic simulation model using 35 years of meteorlogical data yielded flood flow discharge-frequency relationships for each of the 10 selected locations in the basin. Table 19 presents the 5-, 10-, 25-, 50-, 100-, and 500-year flood flow discharges for each of the 10 sites. Supplemental computations yielded 100-year recurrence interval flood stages at each of 10 locations in the basin as set forth in Table 20. Graphical discharge-frequency relationships for the four selected locations are presented in Figure 8 to Figure 11.

Figure 10

SIMULATED DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE LITTLE MENOMONEE RIVER AT THE OZAUKEE-MILWAUKEE COUNTY LINE (RIVER MILE 6.95) UNDER HISTORIC, EXISTING, AND FUTURE CONDITIONS



Source: SEWRPC.

Uncontrolled Development Within Floodlands

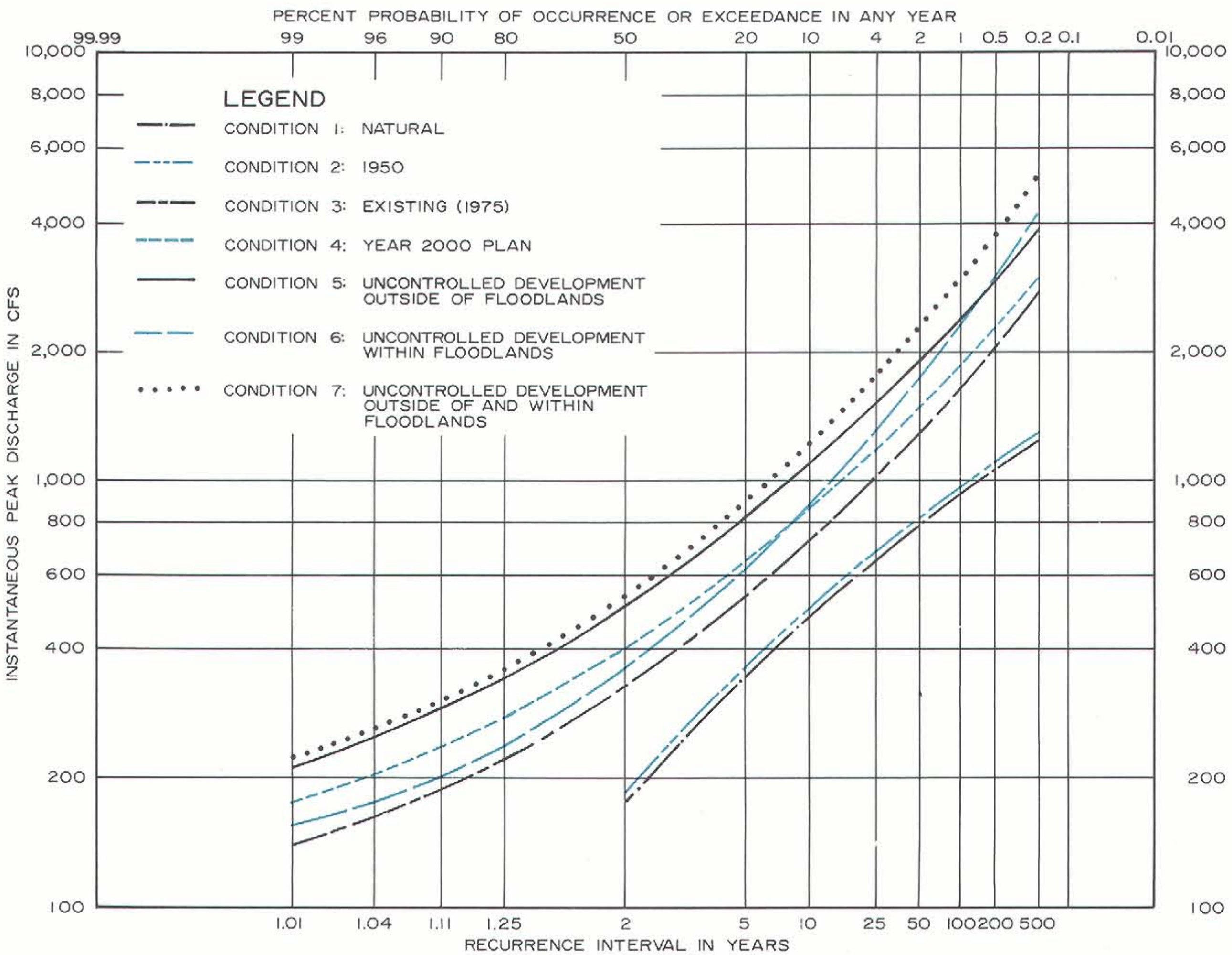
Condition 6 assumes that the existing land use pattern would prevail outside of the floodland areas of the watershed—that is, there would be no additional urban development in that portion of the watershed lying outside of the floodlands—and complete fill and development of the floodland areas would occur. While concentration of all future urban development within the watershed in the floodland areas is not realistic even in the absence of sound planning, simulation of Condition 6 serves to illustrate the hydrologic-hydraulic impact of filling and developing the remaining open floodplains of the watershed. The watershed land surface was represented as it was for the existing condition simulation run, as shown on Map 79, Volume 1 of this report. The 72 lineal miles of floodland in the modeled portion of the watershed stream system were represented by 39 stream reaches.

Floodland fill and development in those portions of the watershed stream system not yet channelized or otherwise developed and filled were represented by assuming that floodland fill would be carried inward from the edge of the floodland to the edge of the stream and that the face of the floodland fill as the stream bank would have a slope of one vertical to three horizontal, as shown on Figure 6. In addition, it was assumed that the inclined side slopes of the floodland fill would be extended upward so that flood flows up to the 500-year discharge would be conveyed within the confines of the floodland fill.

Application of the hydrologic and hydraulic simulation model using 35 years of undeveloped data yielded flood flow discharge-frequency relationships for each of the 10 selected locations in the basin. Supplemental computations yielded 100-year recurrence interval flood stages at each

Figure 11

SIMULATED DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE UNDERWOOD CREEK AT THE WAUKESHA-MILWAUKEE COUNTY LINE (RIVER MILE 2.53) UNDER HISTORIC, EXISTING, AND FUTURE CONDITIONS



Source: SEWRPC.

of the 10 locations in the basin as set forth in Table 20. Table 19 presents the 5-, 10-, 25-, 50-, 100-, and 500-year flood flow discharges for each of the 10 sites. Graphical discharge-frequency relations for four selected locations are presented in Figure 8 to Figure 11.

Uncontrolled Development Within and Outside of Floodland Areas

With respect to the potential for aggravating existing flood problems and producing serious new flood problems, Condition 7 represents the "worst possible" future condition for the watershed. The condition assumes complete urbanization of the watershed land surface outside of the floodland coupled with complete fill and development of all those floodland areas in the watershed that are not yet channelized or otherwise developed. The watershed land surface was represented exactly as it was for the simulation of Condition 5 whereas the watershed channel system was represented exactly as it was for Condition 6.

Application of the hydrologic and hydraulic simulation model using 35 years of undeveloped conditions yielded flood flow discharge-frequency relationships for each of the 10 selected locations in the basin. Table 19 presents 5-, 10-, 25-, 50-, 100-, and 500-year flood flow discharges for each of the 10 sites. Supplemental computations yielded 100-year recurrence interval flood stages at each of the 10 locations in the basin as set forth in Table 20. Graphical discharge-frequency relations for four selected locations are presented in Figure 8 to Figure 11.

Table 20

HYDRAULIC EFFECT OF ALTERNATIVE FUTURE LAND USE-FLOODLAND DEVELOPMENT CONDITIONS IN THE MENOMONEE RIVER WATERSHED

Location				Land Use-Floodland Development Conditions						
				Condition 4: 2000 Plan	Condition 5 Uncontrolled Development Outside of Floodlands		Condition 6: Uncontrolled Development Within Floodlands		Condition 7: Uncontrolled Development Within and Outside of Floodlands	
Stream	River Mile Range	Description	Recurrence Interval (Years)	Relative to 1975 Conditions (feet)	Relative to 1975 Conditions (feet)	Relative to 2000 Conditions (feet)	Relative to 1975 Conditions (feet)	Relative to 2000 Conditions (feet)	Relative to 1975 Conditions (feet)	Relative to 2000 Conditions (feet)
Menomonee River	0.00- 0.23	Reach Upstream of Confluence with the Milwaukee River	100	0.0	0.0	0.0	0.0	0.0	0.5	0.5
Menomonee River	4.23- 4.43	Reach Upstream of Chicago, Milwaukee, St. Paul, and Pacific Railroad (S-590)	100	0.5	4.5	4.0	3.5	2.5	6.5	5.5
Menomonee River	5.82- 5.96	Reach Downstream of S. 68th Street (S-630)	100	1.0	2.5	1.5	2.0	1.0	3.5	2.5
Menomonee River	8.33- 8.47	Reach Upstream of Paved Ford (S-655)	100	1.0	3.0	1.5	2.0	1.0	4.5	3.5
Menomonee River	12.52-12.88	Reach Upstream of W. Hampton Avenue (S-690)	100	1.5	3.0	1.5	3.0	1.5	8.0	6.5
Menomonee River	23.00-24.00	Reach Upstream and Downstream of County Line Road/CTH Q (S-845)	100	0.5	2.0	1.5	1.5	1.5	4.5	4.5
Little Menomonee River	0.00- 0.52	Reach Upstream of Confluence with the Menomonee River	100	1.5	3.0	1.5	3.0	1.5	9.0	7.5
Little Menomonee River	6.91- 7.08	Reach Upstream of County Line Road (S-1485)	100	0.0	3.0	3.0	4.0	4.0	9.0	9.0
Underwood Creek	2.53- 2.60	Reach Upstream and Downstream United Parcel Service Bridge (S-1230)	100	1.0	3.0	2.0	3.0	1.5	5.0	3.5
Honey Creek	0.00- 0.05	Reach Upstream of Confluence with the Menomonee River	100	0.5	2.5	1.5	1.0	0.5	4.5	3.5
		Maximum Increase in 100-Year Stage		1.5	4.5	4.0	4.0	4.0	9.0	9.0
		Minimum Increase in 100-Year Stage		0.0	0.0	0.0	0.0	0.0	0.5	0.5
		Median Increase in 100-Year Stage		0.75	3.0	1.5	2.5	1.5	4.75	4.0

NOTE: Representative flood stage increase obtained by comparing flood stage profiles over a 0.1 mile reach in the vicinity of the indicated location. In order to avoid a possible bias due to the hydraulic effects of bridges and culverts, flood stage profile comparisons were carried out in the reaches immediately upstream and downstream of crossings.

Source: SEWRPC.

Table 21

THE EFFECT OF PERIOD OF RECORD ON FLOOD FLOWS FOR THE MENOMONEE RIVER AT WAUWATOSA

	Flood Discharges in Cubic Feet Per Second	
Recurrence Interval (Years)	Based on Statistical Analyses of 12 Years of Historic Flood Flows Under Conditions that Approximate Existing Land Use-Floodland Conditions	Based on Statistical Analyses of 35 Years of Simulated Flood Flows Under Existing Land Use-Floodland Conditions[a]
5	5,400	5,800
10	8,000	6,900
25	12,600	9,200
50	17,200	11,200
100	23,000	13,500

NOTE: This table illustrates the expected influence of length of record on flood discharges: short records tend to result in overestimation of flood flows.

[a] *Incorporates the 12 years of historic data inasmuch as the historic streamflow record was the primary basis of the calibration of the Water Resources Simulation Model prior to using the model to generate the 35 year flood flow series.*

Source: SEWRPC.

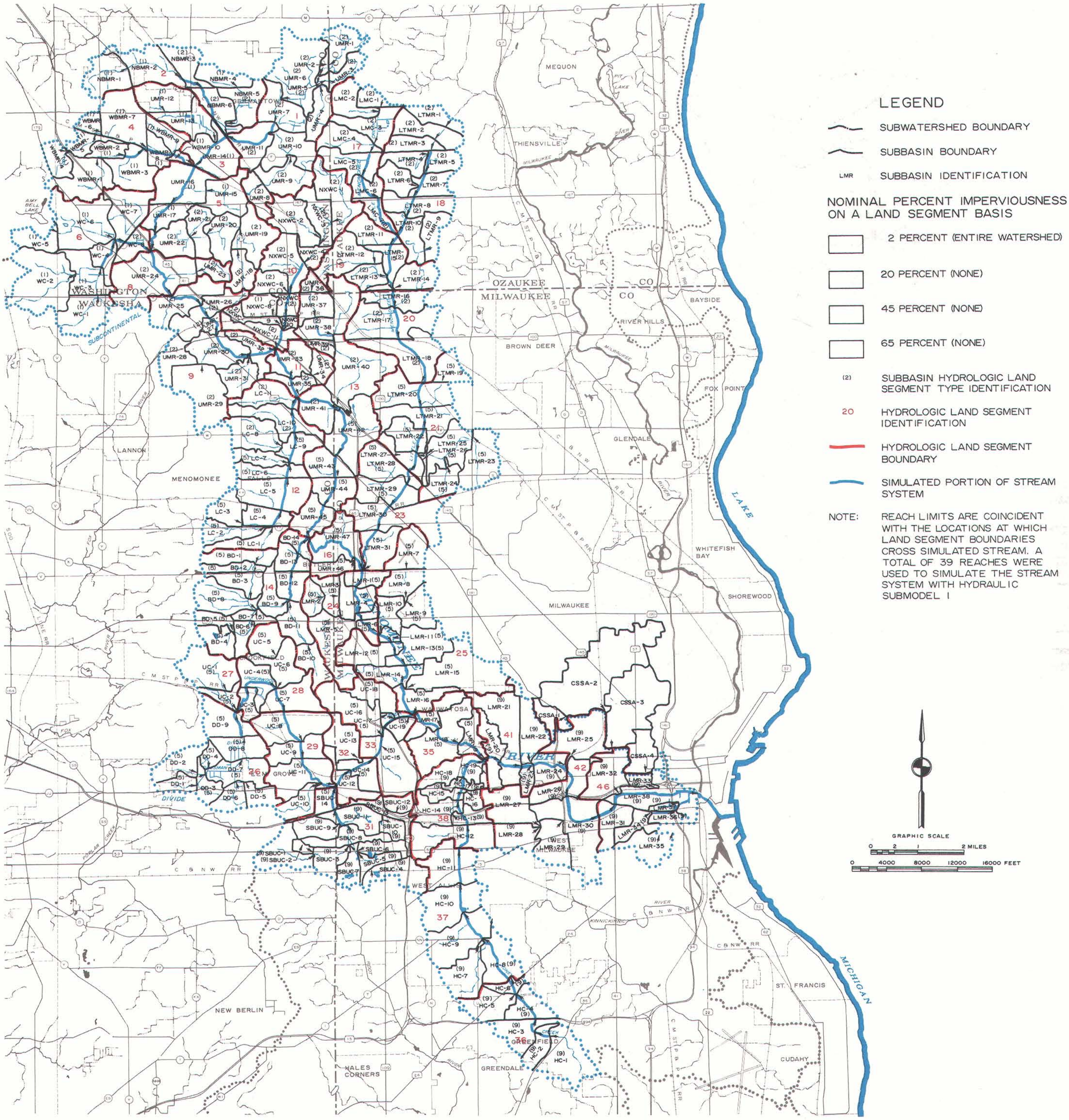
Discussion of the Hydrologic-Hydraulic Response of the Watershed Under Postulated Historic, Existing, and Future Conditions

The 5- through 500-year discharge-frequency data presented in Table 19, the discharge-frequency relationships shown graphically in Figures 8 through 11, and the 100-year flood stage information set forth in Table 20, clearly demonstrate the potential hydrologic-hydraulic impact of alternative land use development conditions. The following discussion draws on the results of the watershed-wide simulation modeling to illustrate various aspects of the impact of land use, both within and outside of the floodlands, on stream flood flow and flood stage characteristics.

Discharge-Frequency Relationships: Figures 8 through Figures 11, which are discharge-frequency relationships for four watershed locations under each of the seven land use-floodland development conditions, are typical of the discharge-frequency relationships that exist or may be expected to exist within the watershed under various watershed development conditions. It may be noted that the various discharge-frequency curves at any location

Map 11

REPRESENTATION OF THE MENOMONEE RIVER WATERSHED FOR HYDROLOGIC-HYDRAULIC SIMULATION: NATURAL CONDITIONS

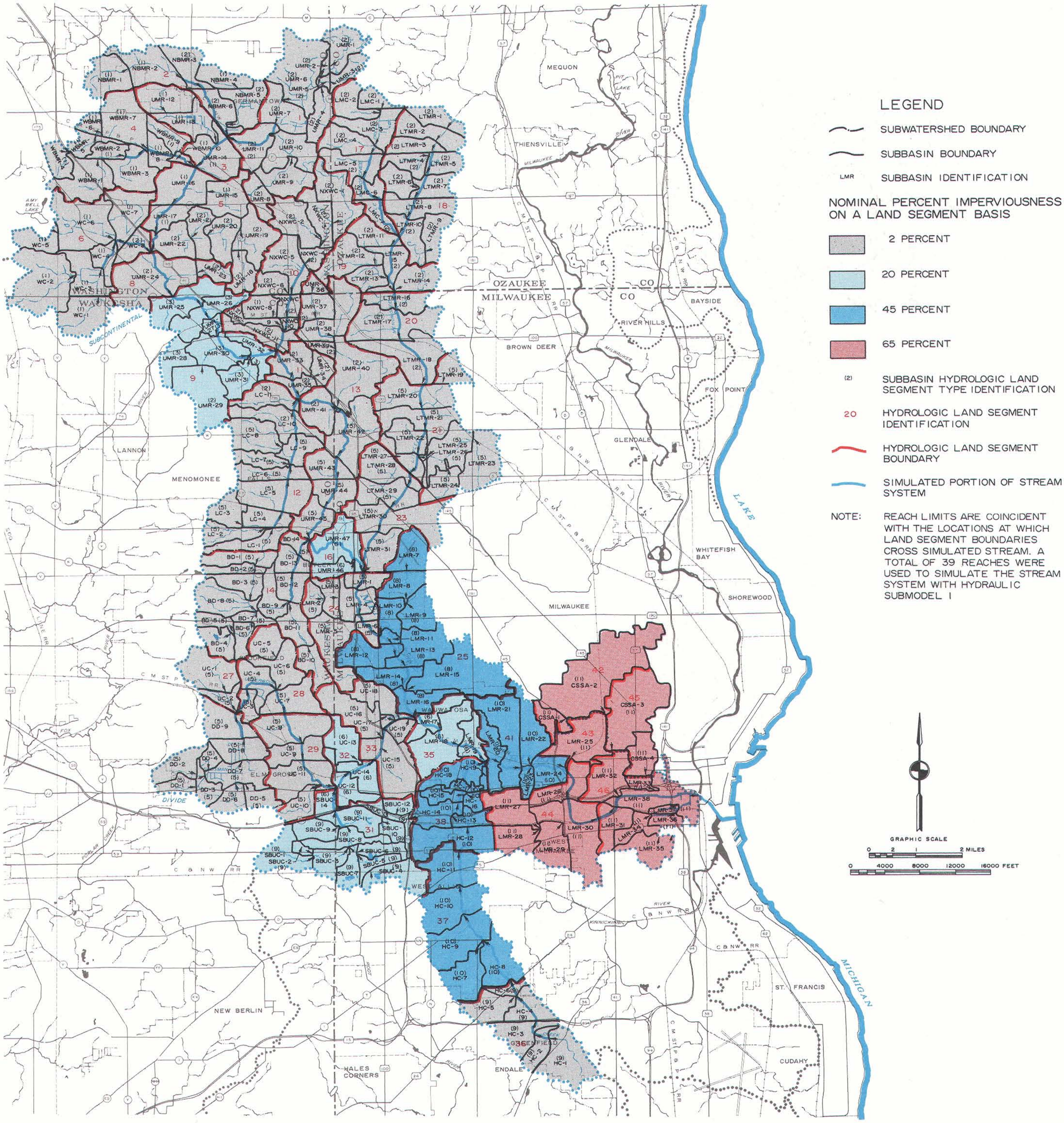


One of the seven land use-floodland conditions combinations simulated under the planning program consisted of a "natural condition" defined as existing conditions minus all impervious surfaces and floodland modifications including channelization. Peak flood flows obtained from simulation of these conditions provided a benchmark against which the effects of existing and possible future land use-floodland development conditions in the watershed could be measured. For 10 locations on the watershed stream system—locations selected so as to be representative of the hydrologic-hydraulic response of the watershed—the ratio of existing condition to natural condition 100-year recurrence interval flood flows ranged from 1.0 to 4.4 with the median value of 1.5.

Source: SEWRPC.

Map 12

REPRESENTATION OF THE MENOMONEE RIVER WATERSHED FOR HYDROLOGIC-HYDRAULIC SIMULATION: 1950 CONDITIONS

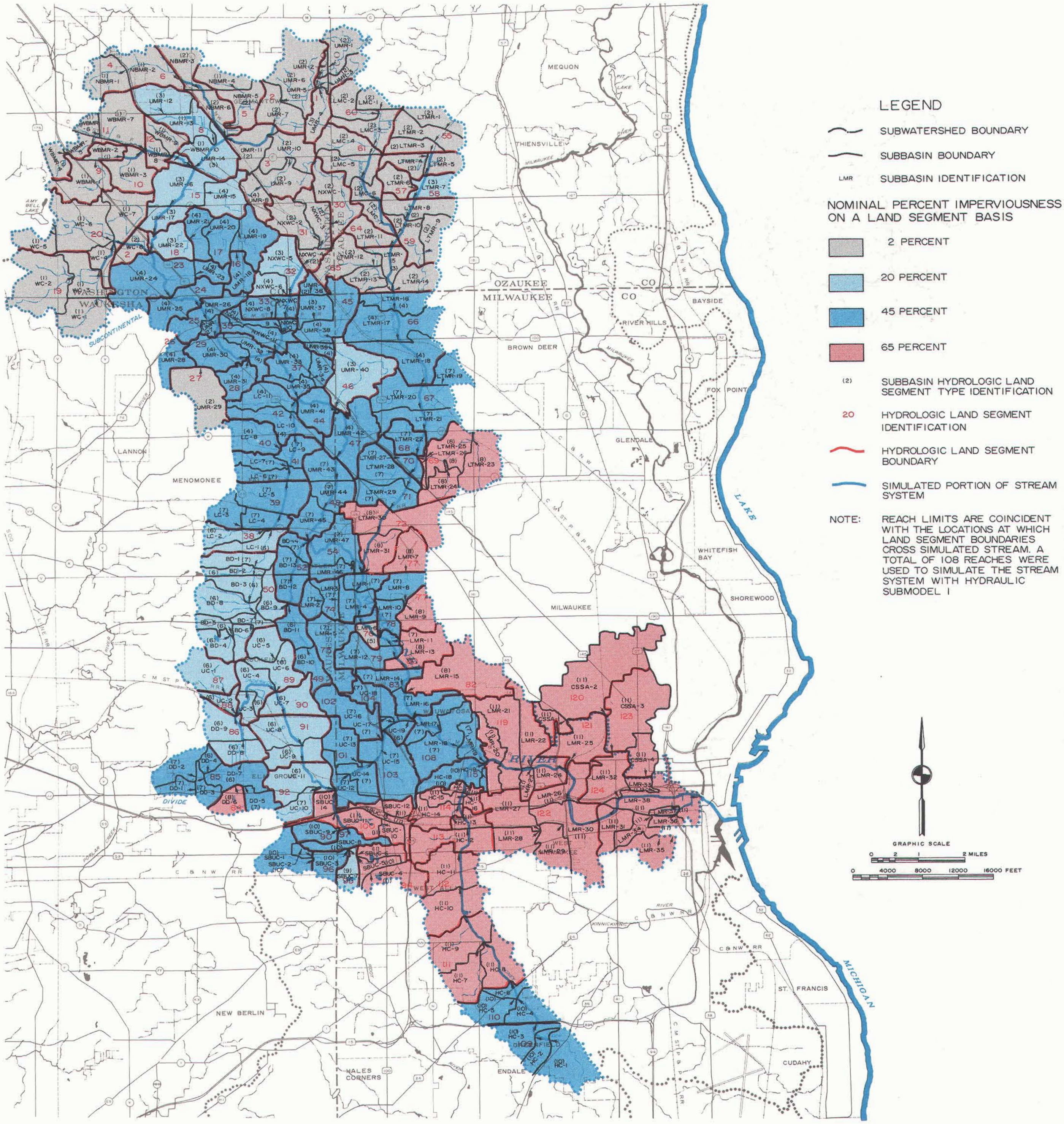


Another land use floodland condition selected for simulation was an approximation of development conditions which existed within the watershed in 1950. This year marks the beginning of an approximately two-decade-long period of rapid population growth and an even more rapid conversion of land from rural to urban land use within the Menomonee River watershed. Simulation results obtained for 1950 conditions as compared to those obtained for existing land use and channel conditions provide a measure of the hydrologic impact of this recent incremental urbanization. For 10 locations on the watershed stream system—locations selected so as to be representative of the hydrologic-hydraulic response of the watershed—the ratio of existing to 1950 100-year recurrence interval flood flows ranged from 1.0 to 1.9 with a median value of 1.5.

Source: SEWRPC.

Map 13

REPRESENTATION OF THE MENOMONEE RIVER WATERSHED FOR HYDROLOGIC-HYDRAULIC SIMULATION: YEAR 2000 PLAN CONDITIONS

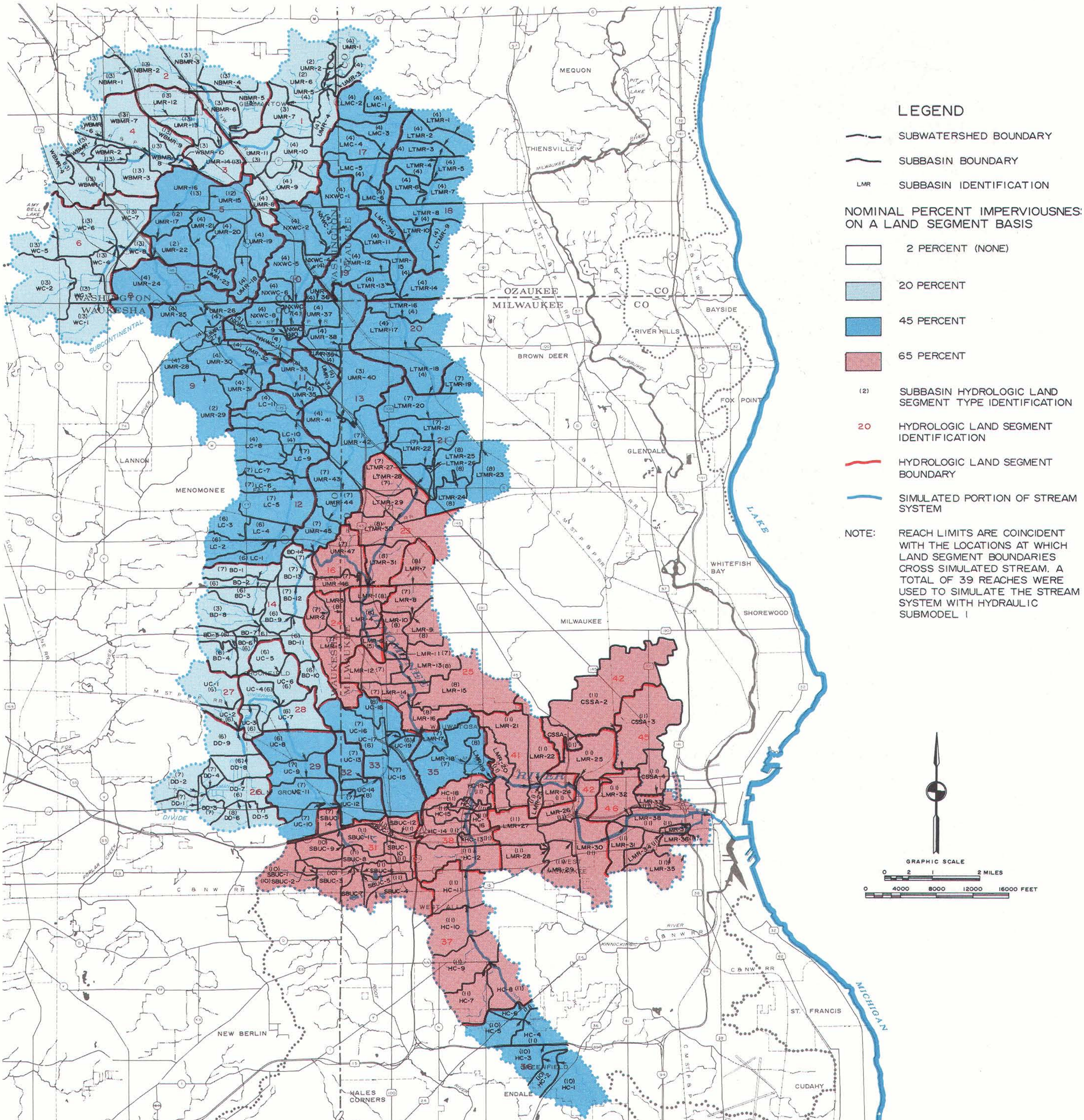


The watershed land surface and stream system were represented as shown for the purpose of simulating the hydrologic-hydraulic behavior of the watershed under year 2000 planned land use conditions in combination with existing channel conditions. Simulation results indicated that year 2000 plan conditions, relative to other land use-floodland development conditions that could occur under uncontrolled development patterns, will have a minimal impact on flood flows throughout the watershed. For 10 locations on the watershed stream system, the ratio of year 2000 plan and existing condition 100-year recurrence interval flood flows ranged from 1.0 to 1.5 with a median value of only 1.1, whereas the median ratio of complete urbanization and existing condition 100-year discharges ranged from 1.4 to 6.4 with a median value of 1.9.

Source: SEWRPC.

Map 14

REPRESENTATION OF THE MENOMONEE RIVER WATERSHED FOR HYDROLOGIC-HYDRAULIC SIMULATION: UNCONTROLLED DEVELOPMENT OUTSIDE OF FLOODLANDS



The watershed land surface and stream system were represented as shown for the purpose of simulating the hydrologic-hydraulic behavior of the watershed under conditions of uncontrolled development outside of the floodlands. Simulation results indicate that such development, in combination with complete development of floodlands, may be expected to markedly increase flood discharges throughout the watershed stream system. For 10 locations on the watershed stream system, the ratio of 100-year recurrence interval flood flows for uncontrolled development within and outside of the floodlands to 100-year flood flows under existing conditions ranges from 1.4 to 6.4 with a median value of 1.9.

Source: SEWRPC.

are approximately parallel with a slight tendency to convergence for the more severe flood events. If the discharge-frequency relationships for any two land use-floodland development conditions at a given location on the watershed system were exactly parallel, then a constant ratio of flood flows would exist between the two conditions. A convergence of discharge-frequency relationships for increasing recurrence intervals means that the ratio of flood flows for the two conditions decreases for more infrequent flood events. Consider, for example, the discharge-frequency relationships for the existing (1975) land use and floodland conditions and the year 2000 planned land use and floodland conditions on the Menomonee River at River Mile 5.96 as shown on Figure 8. The ratio of the year 2000 plan conditions 10-, 50-, and 100-year recurrence interval flood flows to the comparable existing condition flood flows are, respectively, 1.3, 1.3, and 1.2. The relative impact of land use tends to be somewhat less for more rare flood events because the volume and intensity of rainfall and rainfall-snowmelt associated with the more severe floods saturates the pervious portions of the watershed causing those areas to behave in a manner similar to impervious areas.

The Hydrologic Impact of Existing Urban Development Relative to Natural Conditions: A comparison of discharge-frequency relationships for the existing (1975) land use and floodland conditions in the watershed to the discharge-frequency relationships under the postulated "natural" conditions provides a measure of the hydrologic effect of the urban development, both within and outside of the floodlands, that has occurred to date in the Menomonee River watershed. Consider, for example, the discharge-frequency relations developed for the watershed at its point of confluence with the Milwaukee River. The 10-year recurrence interval flood flow discharge under natural conditions at this point is 3,930 cfs compared to existing condition 10-year recurrence interval discharge of 10,300 cfs, the latter being 2.6 times the former. The 100-year recurrence interval discharge at the watershed outlet under natural conditions is 6,400 cfs compared to a 1975 condition 100-year recurrence interval discharge of 19,600 cfs with the latter value being 3.1 times the former. Thus, for the watershed as a whole the urbanization that has occurred to date has produced an approximately threefold increase in the magnitude of major floods.

As might be expected, the relative impact of urbanization to date within the watershed diminishes with distance in an upstream direction along the main stem of the Menomonee River because the fraction of urban development in the respective tributary areas diminishes with distance upstream in the watershed. Consider, for example, flood flow discharges under natural and existing conditions for a point on the Menomonee River immediately upstream of its confluence with the Little Menomonee River. The 10-year recurrence interval discharge at this point under 1975 conditions is 1,660, cfs which is only 1.2 times the natural condition 10-year recurrence interval discharge of 1,410 cfs at this point. The 100-year recurrence interval existing condition discharge at this point is 3,140 cfs, which is only 1.1 times the "natural" condition 100-year recurrence interval discharge of 2,750 at this point.

Considering all of the 10 sites on the watershed stream system selected for analysis purposes, the ratio of 10-year discharges under existing conditions and "natural" conditions ranges from 1.0 to 4.6 with a median value of 1.5. The ratio of 100-year recurrence interval discharges under existing conditions and under natural conditions ranges from 1.0 to 4.4 with a median value of 1.5.

As noted in Chapter IX, Volume 1 of this report, prior to the settlement of the watershed by Europeans, most of the watershed land surface was covered by natural vegetation ranging from woodland, through open prairie, to wetland in type. Inasmuch as the postulated "natural" condition modeling does not represent the presettlement condition vegetation, it is likely that the effect of urbanization to date in the watershed is even more dramatic than illustrated by the above comparison of the "natural" condition discharge-frequency relationships to the existing condition discharge-frequency relationships.

The Significance of Existing Urban Development on the Potential Hydrologic Impact of Additional Urban Development: Given the current development in the watershed, the impact of future urban development outside of the floodland areas on flood flows at any particular point on the stream system, may be expected to increase as the fraction of existing rural land, and therefore the fraction of developable land, in the area tributary to the site increases. This can be demonstrated by selecting certain critical locations on the watershed stream system and comparing the 10 and 100-year recurrence interval discharges for those points under existing conditions to values that would be obtained under Condition 5 which postulates complete urbanization of the watershed land surface outside of the floodlands.

Consider, for example, the site located on Underwood Creek immediately upstream of its confluence with the South Branch of Underwood Creek near the Waukesha-Milwaukee County line. Almost all of the 10.4 square mile area tributary to that point is already urbanized, although under Condition 5, some additional urban development could occur, having the effect of converting some of the low density development in this area to medium density. Under existing conditions, the 10-year recurrence interval discharge for the Underwood Creek at the Waukesha-Milwaukee County line is 725 cfs compared to a Condition 5 discharge of 1,110 cfs, with the latter value being 1.5 times the former. The 1975 condition 100-year discharge at this location is 1,660 cfs whereas, under Condition 5, the discharge would be 2,390 cfs which is 1.4 times the 1975 condition value.

Contrast the hydrologic characteristics of the Underwood Creek site with those for the site located on the Little Menomonee River at the Ozaukee-Milwaukee County line. Almost all of the 10.6 square mile area tributary to that point is currently in rural land use while under Condition 5 the entire area would be developed as medium density residential. Under existing conditions, the 10-year recurrence interval discharge for Little Menomonee River at the Ozaukee-Milwaukee County line is 340 cfs compared to a Condition 5 discharge of 1,140 cfs, with the latter value being 3.4 times the former. The 1975 condition 100-year discharge at this location is 590 cfs whereas under Condition 5 the discharge would be 1,840 cfs which is 3.1 times the 1975 condition value. This illustrates how, for similar sized portions of the watershed, the relative hydrologic impact of future urban development outside of the floodlands increases as the fraction of existing rural land—and therefore developable land—in the tributary area increases.

The Potential Ultimate Impact of Man on the Hydrologic-Hydraulic Response of the Watershed: A comparison of discharge-frequency values for the watershed under postulated "natural" conditions to those that would exist under Condition 7—the "worst possible" condition—serves to illustrate a potential impact that man can have on the flood flow characteristic of the watershed or on a portion of a watershed. Considering the watershed as a whole, the "natural" condition 10-year recurrence interval discharge at the watershed outlet is 3,930 cfs whereas under Condition 7 the 10-year recurrence interval flood flow discharge is 14,500 cfs or 3.7 times the "natural" condition value. The 100-year recurrence interval discharge for the watershed outlet under natural conditions is 6,400 cfs compared to a Condition 7 value of 26,500 cfs which is about 4.1 times the "natural" condition value.

Similar results are obtained for portions of the Menomonee River watershed. For example, consider the flood flow discharges on the main stem of the Menomonee River immediately upstream of its confluence with the Little Menomonee River. The 10-year recurrence interval discharge under "natural" conditions is 1,410 cfs compared to a value of 5,050 cfs—3.6 times the 10-year value—under ultimate development conditions. The 100-year recurrence interval discharge at this location under "natural" conditions is 2,750 cfs compared to an ultimate development condition value of 9,000 cfs which is 3.3 times the 10-year value.

The potential impact of man is even more striking on the upper portion of the Little Menomonee River as indicated by a comparison of "natural" condition and Condition 7 flood flows at the Ozaukee-Milwaukee County line. The 10-year recurrence interval discharge under "natural" conditions at that location is 340 cfs compared to the ultimate development 10-year recurrence interval discharge of 2,150 cfs, the latter of which is 6.3 times the former. The 100-year recurrence interval discharge under "natural" conditions at this location is 590 cfs compared to ultimate development condition 100-year recurrence interval discharge of 3,750 cfs, which is 6.4 times the 10-year value.

Considering the hydrologic results at all the 10 selected sites on the stream system, the ratio of the 10-year discharge under Condition 7 and "natural" conditions ranges from 2.6 to 6.3 with a median value of 3.8. The ratio of 100-year recurrence interval discharges under Condition 7 and under "Natural Conditions" ranges from 3.2 to 6.4 with a median value of 4.0.

The Hydrologic-Hydraulic Consequences of the Year 2000 Land Use Plan: Regional and watershed population and land use forecasts indicate that the Menomonee River watershed will probably have to accommodate, by the year 2000, a 12 percent increase in population and a 21 percent increase in urban land use. The year 2000 land use plan is intended to strike a balance between man's need for space within the watershed and the ability of the underlying natural resource base of the watershed to sustain those needs without a significant loss in the overall quality of life in the urban area. With respect to existing and potential flood problems, there is concern over the hydrologic-hydraulic consequences of the incremental urban development associated with the land use plan. More specifically, it is necessary to know how much larger flood flows and how much higher attendant flood stages may be under year 2000 plan land use and floodland development conditions throughout the watershed relative to the discharges and stages that exist under 1975 conditions. It is important to reiterate that the year 2000 plan recommends no significant additional floodland fill and development.

Considering the watershed as a whole, the year 2000 plan condition 10-year recurrence interval discharge at the watershed outlet is 10,900 cfs which is only about 6 percent larger than the 1975 condition 10-year discharge of 10,300 cfs. There is no significant difference between the 100-year recurrence interval discharge for the watershed outlet under year 2000 plan conditions and the 1975 condition. Therefore, for the watershed as a whole, flood flow characteristics under year 2000 plan land use and floodland development conditions can be expected to be very similar to 1975 conditions. A similar conclusion is reached if other locations in the watershed are considered, with the exception of the main stem of the Menomonee River immediately above its confluence with the Little Menomonee River.

The upper Menomonee River passes through the Villages of Germantown and Menomonee Falls, two civil divisions that will, under the land use plan, absorb much of the additional urban development in the watershed. As a consequence of that development, the upper Menomonee River and its tributaries may be expected to exhibit flood flow increases that are larger than those forecast for the remainder of the watershed stream system. Consider, for example, flood flow discharges and stages on the main stem of the Menomonee River immediately upstream of its confluence with the Little Menomonee River. The 10-year recurrence interval discharge under year 2000 plan conditions is 2,830 cfs which is 1.7 times the 1975 conditions value of 1,660 cfs. Similarly, the year 2000 plan condition 100-year recurrence interval discharge at that location is 4,730 cfs which is 1.5 times the 1975 condition value of 3,140 cfs. The year 2000 plan condition 100-year flood stage profile at that location would be about 1.5 feet above the 1975 condition value.

Considering the hydrologic results for all 10 sites selected for comparison purposes, the ratio of 10-year recurrence interval discharges under year 2000 plan conditions and under existing conditions ranges from 1.0 to 1.7 with a median value of only 1.2 while the ratio of 100-year recurrence interval discharges under the year 2000 plan and under existing conditions ranges from 1.0 to 1.5 with a median value of only 1.1. The associated increase in 100-year recurrence interval flood stage profile ranges from 0.0 feet to 1.5 feet with a median value of 0.75 feet. In summary, then, the year 2000 land use plan may be expected to yield acceptable increases in flood flow discharges and in flood stages throughout the watershed. The anticipated incremental discharges and stages are relatively small compared to those which could occur under uncontrolled development conditions in the watershed.

MONETARY FLOOD RISKS FOR SELECTED FLOOD-PRONE REACHES

The economic analysis of alternative floodland management measures requires that the flood damage susceptibility of a river reach be quantified in monetary terms for comparison to the cost of the alternative floodland management measures. As discussed in Chapter VI, Volume 1, of this report, the average annual flood damage risk expressed in dollars was selected as the uniform, quantitative means of expressing flood damages for the purpose of the Menomonee River watershed study. The average annual flood risk was computed for selected reaches to provide a monetary value that could be used, wholly or in part, as an annual benefit for comparison to the annual costs of technically feasible alternative floodland management plan elements.

Reach Selection

A two-step procedure was utilized to select those stream reaches in the Menomonee River watershed for which monetary flood risks were to be determined. The first step involved the examination of the results of the historic flood survey to identify those reaches that have actually experienced serious flood problems as a result of direct damage to riverine area structures from primary flooding, secondary flooding, or a combination of the two. This resulted in identification of reaches located primarily in the lower portion of the watershed.

The second step in identifying reaches for which monetary flood risks were to be determined involved the examination of the results of the hydrologic-hydraulic simulation modeling for existing and year 2000 plan land use conditions. This led to the identification of additional reaches in which the 100-year recurrence interval flood stage could be expected to cause primary or secondary flooding of a relatively large number of riverine area structures. The simulation model incorporates two factors not reflected in the historic flood data. The first such factor is the spatial variation of precipitation. For example, the amount of rainfall which fell on lower portions of the watershed prior to and during the April 21, 1973, flood of record at the Wauwatosa gaging station—as described in Chapter V, Volume 1 of this report—was relatively large as compared to the amount of rainfall which fell on the upper portions of the watershed. Consequently, this rainstorm produced only moderate flood discharges and stages in the Village of Menomonee Falls. The simulation modeling indicates that the Village of Menomonee Falls may be expected to experience substantially higher flood stages during a 100-year recurrence interval event than were observed during the April 21, 1973, flood of record. The second such factor relates to the changing land use conditions and attendant hydrologic effects which are reflected in the simulation of year 2000 plan conditions. Headwater reaches, such as the upper portion of the Menomonee River and of Underwood Creek, are more likely to be affected by additional urbanization of tributary drainage areas than are the lower reaches of the watershed which already receive a relatively large proportion of runoff from urban land uses.

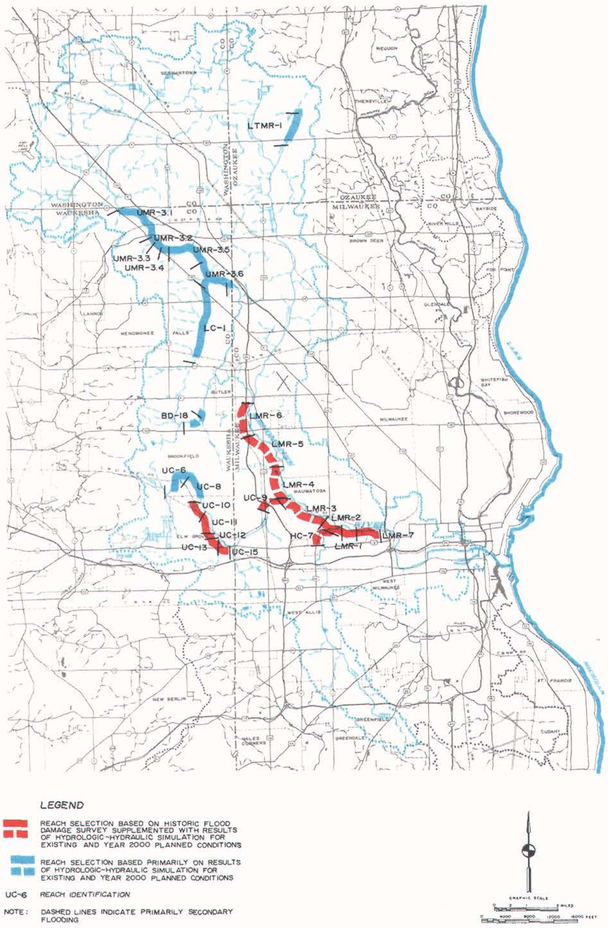
The 25 reaches identified by the above two-step procedure are shown on Map 15 and consist of the entire length of Underwood Creek in the Village of Elm Grove; portions of Underwood Creek and Butler Ditch in the City of Brookfield; portions of Underwood Creek, the Menomonee River, and Honey Creek in the City of Wauwatosa; a portion of the Menomonee River in the City of Milwaukee; portions of Lilly Creek and the Menomonee River in the Village of Menomonee Falls; and a portion of the Little Menomonee River in the City of Mequon.

Map 15 also indicates those reaches in which secondary flooding is the principal cause of the flood problems relative to those reaches in which flood damage is attributable to both primary and secondary flooding. It is apparent that most of the reaches may be expected to experience both primary and secondary flooding with the exception of portions of Honey Creek, Underwood Creek, and the Menomonee River within the City of Wauwatosa and Butler Ditch in the City of Brookfield where secondary flooding is dominant. Additional information about the selected flood-prone reaches, including a description of the upstream and downstream end of each reach and the length of each reach, is set forth in Table 22. The selected reaches have a total length of 24.3 miles, or 34 percent of the 72 miles of watershed stream system selected for hydrologic-hydraulic simulation modeling.

It is important to recognize that there are other areas in the Menomonee River watershed that have experienced serious flood problems that have either been substantially reduced or that continue to experience localized storm water problems. Examples of the former include the portion of the Menomonee River industrial valley west of the 27th Street viaduct where private industry has constructed dikes and floodwalls to provide protection against major flood events and the 2.3-mile-long reach of Honey Creek within the Cities of West Allis and Milwaukee where a major channel enclosure has substantially reduced flood problems. An example of the latter condition, localized flood problems, includes nonriverine lands in the Honey Creek subwatershed that have experienced localized storm water problems. The areas selected for computation of monetary flood risks are those that would experience serious flood problems as a result of a 100-year flood event under year 2000 plan conditions. The selected areas do, therefore, exclude river reaches in which historic flood problems have been largely resolved and they also exclude watershed areas that exhibit

Map 15

REACHES SELECTED FOR COMPUTATION OF AVERAGE ANNUAL FLOOD DAMAGE RISK IN THE MENOMONEE RIVER WATERSHED



A two-step procedure was used to select reaches for computation of monetary flood risks under existing and hypothetical and future conditions. First, examination of the results of historic flood surveys helped to identify those reaches that have actually experienced serious flood problems. Second, results of hydrologic-hydraulic simulation modeling for existing and year 2000 plan land use conditions identified additional flood-prone areas. This two-step procedure led to the identification of 25 flood-damage-prone reaches as shown on the map. Alternative structural and nonstructural floodland management measures were examined for many of these reaches.

Source: SEWRPC.

storm water system deficiencies. Flood problems and storm water problems are defined and contrasted in Chapter VI, Volume 1, of this report.

Monetary Flood Risks

The economic submodel which is described in Chapter VIII, Volume 1 of this report, was used to calculate the sum of the direct and indirect monetary flood risks for each of the above 25 flood-prone reaches. The risk computations were carried out for five land use-floodland development conditions: Existing (1975) Conditions (Condition 3), Year 2000 Plan Conditions (Condition 4), Uncontrolled Development Outside of the Floodlands (Condition 5), Uncontrolled Development Within the Floodlands (Condition 6), and Uncontrolled Development Within and Outside of the Floodlands (Condition 7).

In all cases, the calculations assume that no additional flood-prone development will be constructed in floodlands; that is, if additional floodland development is constructed; as would be probable under Conditions 6 and 7, it is assumed that the structures involved would be floodproofed or otherwise protected against flood damage. Thus, the computed monetary flood risks for any given reach are quite conservative, that is, low relative to the floodland conditions that are likely to prevail inasmuch as the computations assume very strict control over the form, if not the location, of additional urban development in the flood-prone areas.

The results of the analysis for Conditions 6 and 7 must be interpreted carefully. With respect to the future condition of the watershed floodlands, both of these hypothetical situations assume that the floodlands will be filled and otherwise developed to the extent that essentially all of the floodwater conveyance and storage capability of those areas will be lost. For purposes of monetary flood risk calculations, it is assumed that such complete floodland development occurs in all reaches upstream of the reach in question. For example, the average annual flood risk computed under 6 and 7 for Reach UC-13 along the Underwood Creek in the Village of Elm Grove assumes that all upstream reaches are filled and developed.

The results of the monetary flood risk analysis for the 25 selected flood-prone reaches are set forth in Table 23. For each reach and each of the five land use-floodland development conditions, the Table presents the average annual flood damage risk as well as the flood damage risks associated with the 10- and 100-year recurrence interval flood stages. While the average annual flood damage risk was determined for use in the economic analyses of alternative floodland management measures, the flood damage risk associated with the 10- and 100-year recurrence interval flood events is presented to show the monetary losses that can be expected to accompany a given major flood event along the Menomonee River. Adverse annual flood damage risks are depicted in graphic form on Map 16, while existing and potential average annual and 100-year recurrence interval flood damages are summarized on Map 17.

Table 23 also presents the estimated monetary flood damages associated with the April 21, 1973, flood event—the flood of record in the Menomonee River watershed. April 21, 1973, flood event damages in the Village of Elm Grove, the City of Brookfield, along Honey Creek and downstream of Harwood Avenue in the City of Wauwatosa, and the City of Mequon closely approximate the loss that would be incurred as a result of a 100-year recurrence interval flood event. In other flood-prone reaches of the watershed,

Table 22

REACHES SELECTED FOR COMPUTATION OF AVERAGE ANNUAL FLOOD RISKS IN THE MENOMONEE RIVER WATERSHED

Civil Division	Stream	I. D. Number	Upstream End: State, Highway, or Other Location	Upstream End: River Mile	Downstream End: Street, Highway, or Other Location	Downstream End: River Mile	Length (Miles)
Village of Elm Grove	Underwood Creek	UC-10	North Avenue	4.82	Gebhardt Road Extended	4.24	0.58
		UC-11	Gebhardt Road Extended	4.24	Juneau Boulevard	3.67	0.57
		UC-12	Juneau Boulevard	3.67	Chicago, Milwaukee, St. Paul, and Pacific Railroad	3.56	0.11
		UC-13	Chicago, Milwaukee, St. Paul, and Pacific Railroad Upstream of Watertown Plank Road	3.56	Chicago, Milwaukee, St. Paul, and Pacific Railroad Downstream of Wall Street	3.10	0.46
		UC-15	Chicago, Milwaukee, St. Paul, and Pacific Railroad Downstream of Wall Street	3.10	Confluence with Paved Portion of Underwood Creek	2.53	0.57
City of Brookfield	Underwood Creek	UC-6	Pilgrim Road	6.68	900 Feet Downstream of Clearwater Drive	5.43	1.25
		UC-8	900 Feet Downstream of Clearwater Drive	5.43	North Avenue	4.82	0.61
	Butler Ditch	BD-18	West Boundary of SE 1/4 Section 2, T7N, R20E	2.28	Lisbon Road	1.02	1.26
Village of Menomonee Falls	Lilly Creek	LC-1	Chicago Northwestern Railroad	2.59	Confluence with Upper Menomonee River	0.00	2.59
	Upper Menomonee River	UMR 3-1	County Line Road (CTH Q)	23.47	State Highway 74	21.93	1.54
		UMR 3-2	State Highway 74	21.93	Jacobson Drive Extended	21.65	0.28
		UMR 3-3	Jacobson Drive Extended	21.65	700 Feet West of Pilgrim Road	21.25	0.40
		UMR 3-4	700 Feet West of Pilgrim Road	21.25	Margaret Road Extended	20.93	0.32
		UMR 3-5	Margaret Road Extended	20.93	Lilly Road	19.74	1.19
		UMR 3-6	Lilly Road	19.74	Milwaukee-Waukesha County Line	17.95	1.79
City of Wauwatosa	Menomonee River	LMR-1	N. 68th Street	5.96	N. 60th Street Extended	5.38	0.58
		LMR-2	Harwood Avenue	6.72	N. 68th Street	5.96	0.76
		LMR-3	North Avenue	8.50	Harwood Avenue	6.72	1.78
		LMR-4	Burleigh Street	9.68	North Avenue	8.50	1.18
		LMR-5	Capitol Drive	11.20	Burleigh Street	9.68	1.52
		LMR-6	Hampton Avenue	12.52	Capitol Drive	11.20	1.32
	Honey Creek	HC-7	W. Wisconsin Avenue	0.91	Confluence with Menomonee River	0.00	0.91
	Underwood Creek	UC-9	USH 45	0.75	Confluence with Menomonee River	0.00	0.75
City of Mequon	Little Menomonee River	LTMR-2	Freistadt Road (CTH M)	10.18	Mequon Road (STH 167)	9.12	1.06
City of Milwaukee	Menomone River	LMR-7	N. 60th Street Extended	5.38	N. 45th Street	4.45	0.93

Source: SEWRPC.

however, such as those along the Menomonee River in the Village of Menomonee Falls, a 100-year recurrence interval flood event could be expected to cause substantially higher flood damages.

THE ECONOMIC CONSEQUENCES OF ALTERNATIVE LAND USE-FLOODLAND DEVELOPMENT CONDITIONS

The foregoing discussion of the impact of urbanization on flood problems in the Menomonee River watershed concentrated on the hydrologic-hydraulic impact—that is, on the expected increases in flood discharge and flood stage associated with various land use configurations within and outside of the floodland areas. Monetary flood risks provide another means of quantifying the consequences of urbanization on watershed flood problems.

The Village of Elm Grove

As set forth in Table 23, the estimated average annual monetary flood risks along Underwood Creek in the Village of Elm Grove under existing conditions; year 2000 plan conditions; and Conditions 5, 6, and 7 are, respectively, $231,800, $362,800, $445,100, $361,900 and $509,500. Average annual monetary flood risks under year 2000 plan conditions are expected to increase to $362,800 per year, a 70 percent increase over the existing condition risk of $213,800 per year. Condition 7—the "worst possible"

Table 23

MONETARY FLOOD RISKS FOR SELECTED REACHES IN THE MENOMONEE RIVER WATERSHED

Reach Description			Monetary Flood Risk in $1,000[a]																		
			Condition 3: Existing Conditions				Condition 4: 2000 Plan			Condition 5: Uncontrolled Development Outside of Floodlands			Condition 6: Uncontrolled Development Within Floodlands			Condition 7: Uncontrolled Development Within and Outside of Floodlands					
Civil Division	Stream	Identification Number	10 Year Recurrence Interval	100 Year Recurrence Interval	April 21, 1973[b]	Average Annual	10 Year Recurrence Interval	100 Year Recurrence Interval	Average Annual	10 Year Recurrence Interval	100 Year Recurrence Interval	Average Annual	10 Year Recurrence Interval	100 Year Recurrence Interval	Average Annual	10 Year Recurrence Interval	100 Year Recurrence Interval	Average Annual			
Village of Elm Grove	Underwood Creek	UC-10	30.0	187.3	132.8	21.0	41.3	243.7	32.3	52.2	297.2	42.0	42.3	268.1	35.3	103.7	442.9	58.2			
		UC-11	10.6	69.7	56.9	8.7	13.3	76.2	9.8	25.7	150.7	14.7	13.7	114.7	10.7	36.2	282.2	20.7			
		UC-12	27.5	128.5	122.9	14.4	75.4	136.9	26.3	104.5	158.2	35.4	77.6	155.2	27.3	113.0	216.5	38.4			
		UC-13	327.2	899.0	827.0	168.4	560.2	959.3	269.8	724.3	1,132.1	312.9	608.0	1,083.4	252.7	782.7	1,524.7	342.0			
		UC-15	36.3	78.8	71.6	19.3	39.4	89.5	24.6	84.9	120.9	40.1	44.4	110.3	35.9	119.2	149.4	50.2			
	Subtotal	--	431.6	1,363.3	1,211.2	231.8	729.5	1,505.6	362.8	991.6	1,859.1	445.1	786.0	1,731.7	361.9	1,154.8	2,615.7	509.5			
City of Brookfield	Underwood Creek	UC-6	84.9	270.6	360.2	43.4	108.5	309.1	58.8	112.7	309.6	89.1	98.2	341.2	60.3	118.3	383.3	97.7			
		UC-8	25.1	66.1	78.3	14.0	26.2	78.3	14.7	76.8	104.2	29.5	29.8	105.9	16.6	107.7	116.5	40.4			
		Subtotal	110.0	336.7	438.5	57.4	134.7	387.4	73.5	189.5	413.8	118.6	128.0	447.1	76.9	226.0	499.8	138.1			
	Butler Ditch	BD-18	2.6	5.6	-	1.8	3.2	9.0	2.3	3.6	5.9	2.5	2.8	7.5	1.8	5.0	7.3	3.2			
	Subtotal	--	--	-	438.5	59.2	-	-	75.8	--	--	121.1	--	--	78.7	-	--	141.3			
Village of Menomonee Falls	Lilly Creek	LC-1	67.2	238.2	-	43.0	200.2	333.5	109.4	221.8	393.6	133.5	132.4	348.8	81.9	330.0	621.6	187.1			
	Menomonee River	UMR 3-1	25.2	82.4	36.4	12.8	33.5	109.1	18.3	106.2	300.9	56.7	34.4	212.1	22.1	214.8	693.3	117.7			
		UMR 3-2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			
		UMR 3-3	9.5	34.2	10.0	8.9	10.0	35.8	9.5	34.2	86.6	18.3	10.0	78.9	10.1	75.0	196.0	44.9			
		UMR 3-4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	4.8	0.3	0.3	0.4	0.2	0.4	6.6	0.7			
		UMR 3-5	9.7	21.9	10.3	4.6	11.3	36.8	8.5	21.9	69.8	12.8	9.9	40.0	5.6	64.8	122.3	28.8			
		UMR 3-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	83.3	2.2	5.3	1.3	45.2	2.3	61.6	247.9	28.6			
		Subtotal	44.4	138.5	56.7	26.3	54.8	181.7	36.3	246.0	464.3	93.4	55.9	376.6	40.3	416.6	1,266.1	220.7			
	Subtotal	--	--	--	56.7	69.3	--	-	145.7	--	--	226.9	--	--	122.2	-	--	407.8			
City of Wauwatosa	Menomonee River	LMR-1	75.5	1,394.7	1,085.5	94.5	324.2	1,877.2	190.6	1,100.9	3,438.3	494.5	352.1	2,457.6	236.9	1,729.3	3,166.9	624.4			
		LMR-2	54.4	702.2	828.6	52.5	341.4	933.6	140.3	540.1	1,378.5	226.1	147.0	1,110.7	99.0	683.7	2,092.8	295.2			
		Subtotal	129.9	2,096.9	1,914.1	147.0	665.6	2,810.8	330.9	1,641.0	4,816.8	720.6	499.1	3,568.3	335.9	2,413.0	5,259.7	919.6			
		LMR-3	1.6	67.5	255.0	4.6	4.6	226.3	11.7	10.6	529.3	26.3	4.0	341.3	15.0	41.8	834.6	51.9			
		LMR-4	65.6	149.5	125.5	50.8	87.9	241.8	65.9	108.2	358.5	78.8	104.5	471.5	77.9	202.4	688.8	126.5			
		LMR-5	47.2	131.1	299.6	23.8	83.0	231.7	47.8	94.6	385.3	68.1	91.4	468.2	56.3	376.6	1,126.4	195.4			
		LMR-6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.4	0.0	0.3	13.5	1.2			
	Subtotal		114.4	348.1	680.1	79.2	175.5	699.8	125.4	213.4	1,273.4	173.2	199.9	1,281.4	149.2	621.1	2,663.3	375.0			
	Honey Creek	HC-7	0.8	3.9	3.4	0.5	1.3	3.8	0.7	2.4	5.5	1.0	0.9	5.4	0.6	2.2	5.7	1.0			
	Underwood Creek	UC-9	2.1	25.4	9.8	2.6	3.5	64.6	3.9	22.8	175.3	15.9	4.4	113.2	7.9	25.9	314.5	28.7			
	Subtotal	--	--	-	2,607.4	229.3	--	--	460.9	--	--	910.7	--	--	493.6	--	--	1,324.3			
City of Mequon	Little Menomonee River	LTMR-2	9.6	16.4	14.6	2.3	9.6	16.4	2.3	137.7	236.6	29.0	27.3	129.2	9.5	177.9	187.8	34.1			
City of Milwaukee	Menomonee River	LMR-7	10.0	728.2	80.5	38.6	35.0	841.9	48.6	364.0	1,426.0	163.6	66.9	1,201.2	74.7	505.1	1,929.7	224.0			
Total	--	--	--	-	4,408.9	630.5	-	--	1,096.1	--	--	1,896.4	--	--	1,140.6	--	--	2,641.0			

[a] *Includes direct damage to structures and contents plus indirect damages associated with that structural damage.*

[b] *Based on historic flood stages available.*

Source: SEWRPC.

situation—risks are conservatively estimated to increase to $509,500 per year, a 140 percent increase over the existing conditions risk.

The City of Brookfield

As set forth in Table 23, the estimated average annual flood risk along portions of Underwood Creek and Butler Ditch in the City of Brookfield under existing conditions, year 2000 plan conditions, Condition 5, Condition 6, and Condition 7 are respectively, $59,200, $75,800, $121,100, $78,700, and $141,300. Average annual monetary flood risks under year 2000 plan conditions are expected to increase to $75,800 per year, a 28 percent increase over the existing condition risk of $59,200 per year. In contrast, under Condition 7, average annual monetary flood risks are conservatively estimated to increase to $141,300 per year, a 140 percent increase over the existing conditions risk.

The Village of Menomonee Falls

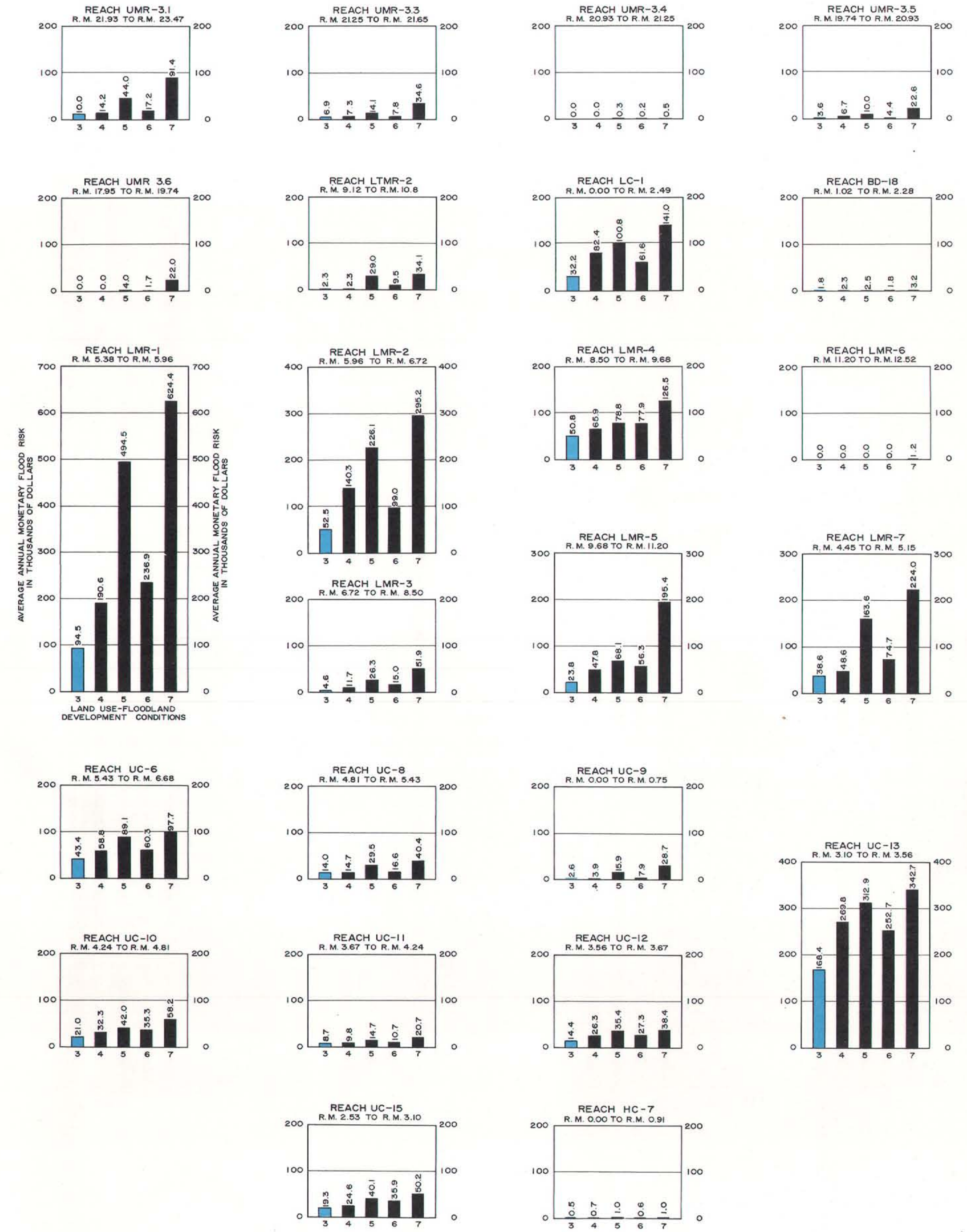
As set forth in Table 23, the estimated average annual flood risks along the Menomonee River, Lilly Creek, and Nor-X-Way Channel in the Village of Menomonee Falls under existing conditions, year 2000 plan conditions, Condition 5, Condition 6, and Condition 7 are, respectively, $69,300, $145,700, $226,900, $122,200, and $407,800. Average annual monetary flood risks under year 2000 plan conditions are expected to increase to $145,700 per year, an 110 percent increase over the existing condition risk of $69,300 per year. In contrast, under Condition 7, average annual monetary flood risks are conservatively projected to increase to $407,800 per year, a 490 percent increase over the existing conditions risk.

The City of Wauwatosa

As set forth in Table 23, the estimated average annual flood risks along the Menomonee River, Underwood Creek, and

Map 16

THE EFFECTS OF URBANIZATION ON AVERAGE ANNUAL FLOOD DAMAGES IN THE MENOMONEE RIVER WATERSHED

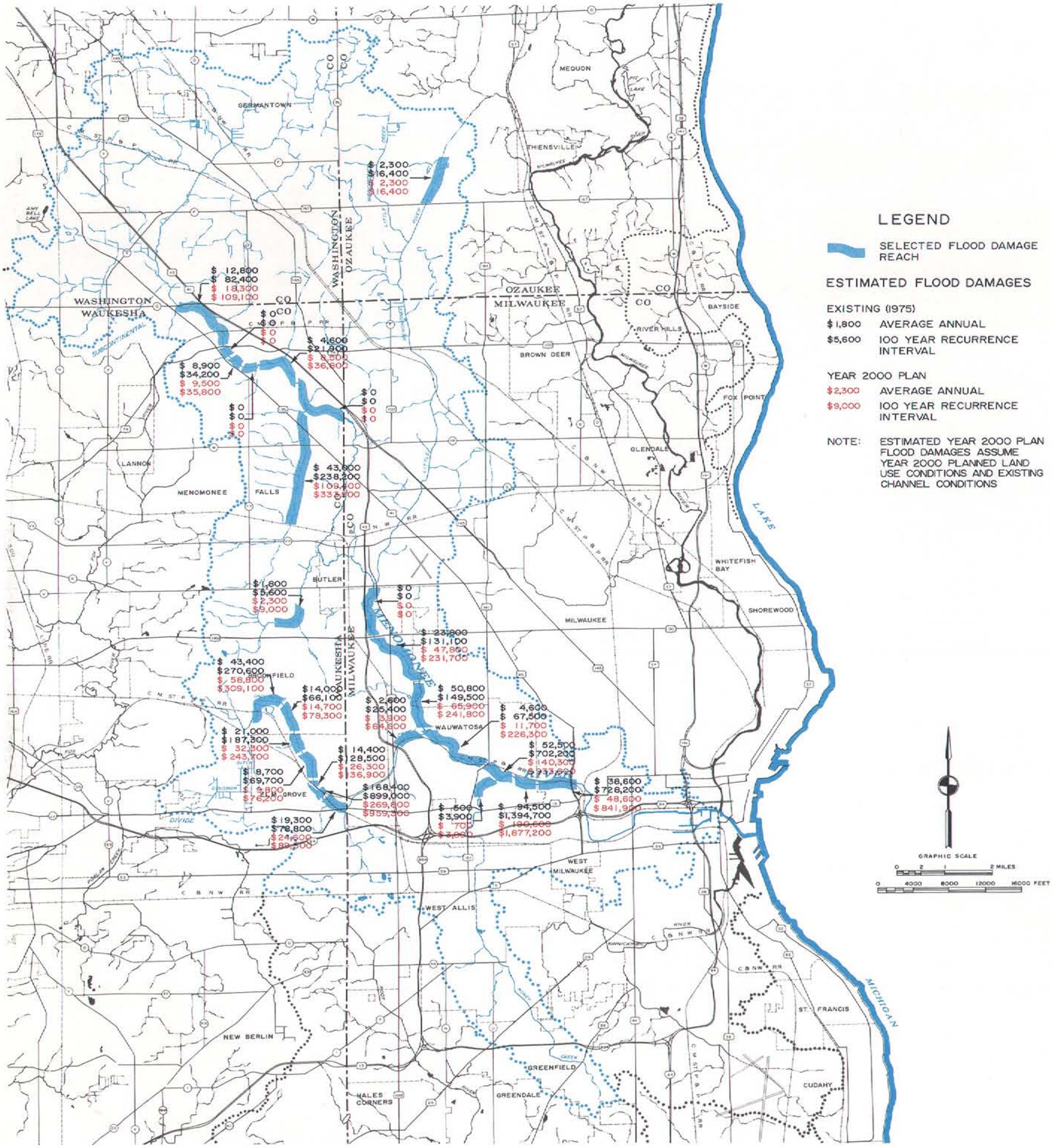


Analyses conducted under the watershed planning program revealed that future urban development—both within and outside of floodland areas—has the potential to significantly increase monetary flood damages to existing flood-prone reaches in the watershed. If the remaining undeveloped floodland and nonfloodland areas are developed, average annual flood damages to existing flood-prone areas in the watershed are conservatively estimated to increase by 330 percent. While a much smaller 80 percent increase in average annual flood damages would be expected under year 2000 land use plan conditions, the comprehensive plan for the Menomonee River watershed contains recommendations for structural and nonstructural floodland management measures to mitigate existing flood problems and to prevent aggravation of those problems under planned land use conditions.

Source: SEWRPC.

Map 17

EXISTING AND YEAR 2000 LAND USE PLAN AVERAGE ANNUAL AND 100-YEAR RECURRENCE INTERVAL FLOOD DAMAGES ALONG SELECTED STREAM REACHES IN THE MENOMONEE RIVER WATERSHED



Existing and potential future flood damages for flood-prone stream reaches in the Menomonee River watershed are identified on the above map. On an average annual basis, flood damages over the watershed as a whole could be expected to increase by about 75 percent under planned land use and existing channel conditions, from about $0.63 million in 1975 to about $1.1 million in 2000. If 100-year recurrence interval flood discharges occurred over the entire watershed—that is, flood flows similar in severity to the 1973 flood along the Menomonee River in Wauwatosa—flood damages could be expected to rise by about 29 percent, from about $5.3 million at present to about $6.9 million in the year 2000.

Source: SEWRPC.

Honey Creek in the City of Wauwatosa under existing conditions, year 2000 plan conditions, Condition 5, Condition 6, and Condition 7 are, respectively, $229,300, $460,900, $910,700, $493,600, and $1,324,300. Average annual monetary flood risks under year 2000 plan conditions are expected to increase to $460,900 per year, a 100 percent increase over the existing condition risk of $229,200 per year. In contrast, under Condition 7, average annual monetary flood risks are conservatively estimated to increase to $1,324,300 per year, a 480 percent increase over the existing conditions risk.

The City of Mequon

As set forth in Table 23, the estimated average annual flood risk along the Little Menomonee River in the City of Mequon for existing conditions, year 2000 plan conditions, Condition 5, Condition 6, and Condition 7 are, respectively, $2,300, $2,300, $29,000, $9,500, and $34,100. Average annual monetary flood risks under year 2000 plan conditions are not expected to increase above the existing condition risk of $2,300 per year. In contrast, under Condition 7, average annual monetary flood risks are conservatively estimated to increase to $34,100 per year, a 1,400 percent increase over the existing conditions risk.

The City of Milwaukee

As set forth in Table 23, the estimated average annual flood risk along the Milwaukee River in the City of Milwaukee for existing conditions, year 2000 plan conditions, Condition 5, Condition 6, and Condition 7 are, respectively, $38,600, $48,600, $163,600, $74,700, and $224,000. Average annual monetary flood risks under year 2000 plan conditions are expected to increase to $48,600 per year, a 26 percent increase relative to the existing condition risk of $38,600 per year. In contrast, under Condition 7, average annual monetary flood risks are conservatively estimated to increase to $224,000 per year, a 480 percent increase over the existing conditions risk.

Concluding Statement

The above community-by-community analysis of average annual flood damages as a function of alternative land use-floodland development conditions in the Menomonee River watershed clearly indicates that monetary flood risks in a given reach may be expected to be very sensitive to dicisions concerning land use development both in the floodlands and in the watershed as a whole. The manner in which presently undeveloped land, both within and outside of the watershed floodlands, is used in the future may be expected to be a primary determinant of future monetary flood damages experienced in the watershed, particularly in the lower portion of the basin. For example, under conditions of complete urbanization of the floodland and nonfloodland areas of the Menomonee River watershed, the average annual flood damage may be expected to increase by a factor of up to 5.7 in some downstream reaches even if no additional flood-prone development is constructed in those riverine areas. In contrast, implementation of the year 2000 land use plan will minimize the incremental average annual flood damages.

FLOODWATER STORAGE ALTERNATIVES

As noted earlier in this chapter, floodwater storage is a structural floodland management measure that has the potential to resolve or significantly minimize flood problems in one or more flood-prone reaches downstream of the impoundment facilities. Under the Menomonee River watershed study, 25 potential surface floodwater storage locations were identified and screened to determine their potential to provide flood protection as well as to possibly accommodate other uses such as water-related recreational activities. Based upon a screening of the 25 sites, 11 were selected for further hydrologic, hydraulic, and economic analyses with the objective of identifying one storage site, or a combination of such sites, that could mitigate flood damages in a technically sound, economically viable, and environmentally acceptable manner. In addition, the feasibility of storing floodwater in a mined storage chamber beneath the watershed was examined.

For purposes of the preliminary identification and initial evaluation of potential surface storage sites in the watershed, each site was viewed as a detention reservoir, as opposed to a retention reservoir. A detention reservoir is defined as a reservoir that is normally dry, or contains very little water—except perhaps enough to achieve an aesthetic purpose—but is designed to fill during flood events, thereby significantly attenuating downstream flood discharges and stages. After the passage of the flood event, a detention reservoir is drained by gravity or by pumping. A retention reservoir, in contrast, is defined as a reservoir that normally contains, at a predetermined conservation pool level, a substantial volume of water available for recreational and other purposes, above which a floodwater storage volume is maintained for utilization during the flood events. The primary reason for assuming detention storage reservoirs, as opposed to the more traditional retention reservoirs, is the relative lack of large surface reservoir sites in the urbanizing Menomonee River watershed and, therefore, the need to make maximum use of the little potential storage that does remain in the basin.

Preliminary Identification of Surface Storage Sites

The preliminary identification of potential floodwater storage sites was initiated by an examination of watershed topography to determine locations at which a relatively large volume of water could be stored, with or without the construction of an impounding structure. Another factor considered in the preliminary identification was the nature of the existing land use and the value of vacant land inasmuch as intensive urban development or high land costs in or near a site would probably, as a practical matter, preclude its use for floodwater storage. A preliminary maximum flood pool elevation was determined for each of the potential sites with the principal determining factor being prevention of inundation to urban land uses or arterial streets contiguous to the sites. This maximum flood pool elevation was used to determine the total floodwater storage volume and the surface area of each site.

Map 18 shows the location of the 25 sites identified in the initial examination of the watershed.[5] Storage site locations and selected data about each site, including surface area, maximum flood pool elevation, and maximum available storage volume, are summarized in Table 24. Of the total of 25 potential floodwater storage sites, 22 are located directly on portions of the watershed stream system whereas three sites—Hartung Quarry in the City of Milwaukee, a gravel pit in the City of Wauwatosa, and a sewage treatment plant site in the Village of Menomonee Falls—are categorized as "off-channel" storage facilities.

Selection of Surface Storage Sites for Further Consideration

Each of the 25 potential sites was subjected to an initial evaluation of its potential, either individually or in combination with other storage facilities, for achieving a significant reduction in flood damages in one or more downstream reaches. As a result of this initial evaluation, and as summarized in Table 24, 13 of the sites were judged to be technically impractical and were therefore eliminated from further consideration.

In addition, Site 11 on Butler Ditch in the City of Brookfield was eliminated from further consideration because a preliminary analysis indicated that, even if a detention storage facility at that site were technically feasible, land acquisition and other development costs could be expected to be very high relative to the flood abatement benefits that might accrue. The site in question, which is located in Section 2, Town 7 North, Range 20 East, at the confluence of Butler Ditch and a tributary from the south, could provide up to about 364 acre-feet of storage with a surface area of 101 acres; equivalent to 2.2 inches of runoff from the 3.06 square mile tributary drainage area.

Land values in this area are likely to vary from about $3,500 to $10,000 per acre with the higher values being applicable to frontage land along W. Capitol Drive which borders the southern edge of the site. Assuming that the site could be acquired at a cost of $3,500 per acre, acquisition of the entire 101 acre site plus an additional 20 acres, to provide site access for maintenance purposes and to allow for refinement in the ultimate taking lines based upon consideration of real property line locations, would entail an expenditure of $423,500. If amortized at an annual interest rate of 6 percent over a period of 50 years, the equivalent average annual cost would be $26,700. This annual cost—without consideration of amortization of the capital costs of necessary control structure and storm water pumping station costs and without annual operation and maintenance cost—is almost 12 times the average annual flood damages of $2,300 which would be abated assuming development of the site. If half the site were acquired, thereby providing for control of approximately 1.1 inches of runoff from the tributary drainage area, amortization of just the site acquisition costs would approximate $13,300 per year, or almost six times the potential benefits that would accrue. In summary, then, Site 11 on Butler Ditch in the City of Brookfield was omitted from further technical and economic consideration because of very high apparent costs relative to the expected benefits.

There is a possibility that detention storage could be provided at Site 11 as part of the acquisition and development of the site for multiple purpose outdoor recreation and open space purposes. About two-thirds of the 101 acre site is currently zoned by the City of Brookfield for either residential or local business use with the remaining one-third being zoned for conservancy use. The land use plan element of the watershed plan recommends that floodland and conservancy zoning be applied in this area to protect the primary environmental corridor lands which encompass much of the potential storage site. It may be possible for the City of Brookfield to use a combination of floodland and conservancy zoning and land acquisition to preserve this area as a carefully designed and managed public outdoor recreation and open space site which has a valuable supplementary function as a floodwater detention area.

This preliminary assessment of technical feasibility included consideration of the volume of each site in combination with its position in the watershed stream system relative to downstream flood-prone reaches. Most of the larger storage sites were retained for further study with the exception of the site on the Little Menomonee River in the City of Mequon at the Ozaukee-Milwaukee County line. This relatively large site was eliminated from further consideration because it lacks potential to significantly reduce flood flows and stages in flood-prone portions of the watershed. Although this site is located upstream of the flood-prone reaches located along the Menomonee River in the City of Wauwatosa, because of the relatively small tributary area and flood flow controlled it was considered unlikely that storage at this location could significantly reduce flood discharges and stages in the City of Wauwatosa. For example, the 100-year recurrence interval discharge under year 2000 plan conditions at this reservoir site is only 580 cfs and very small relative to the 100-year recurrence interval peak flood discharge of 16,800 cfs at the N. 70th Street crossing of the Menomonee River in the City of Wauwatosa. Therefore, although the storage site on the Little Menomonee River at the Ozaukee-Milwaukee County line may be suitable from topographic, land use, and volume perspectives, it does not have the potential to achieve a significant reduction in flood damages in the downstream reaches.

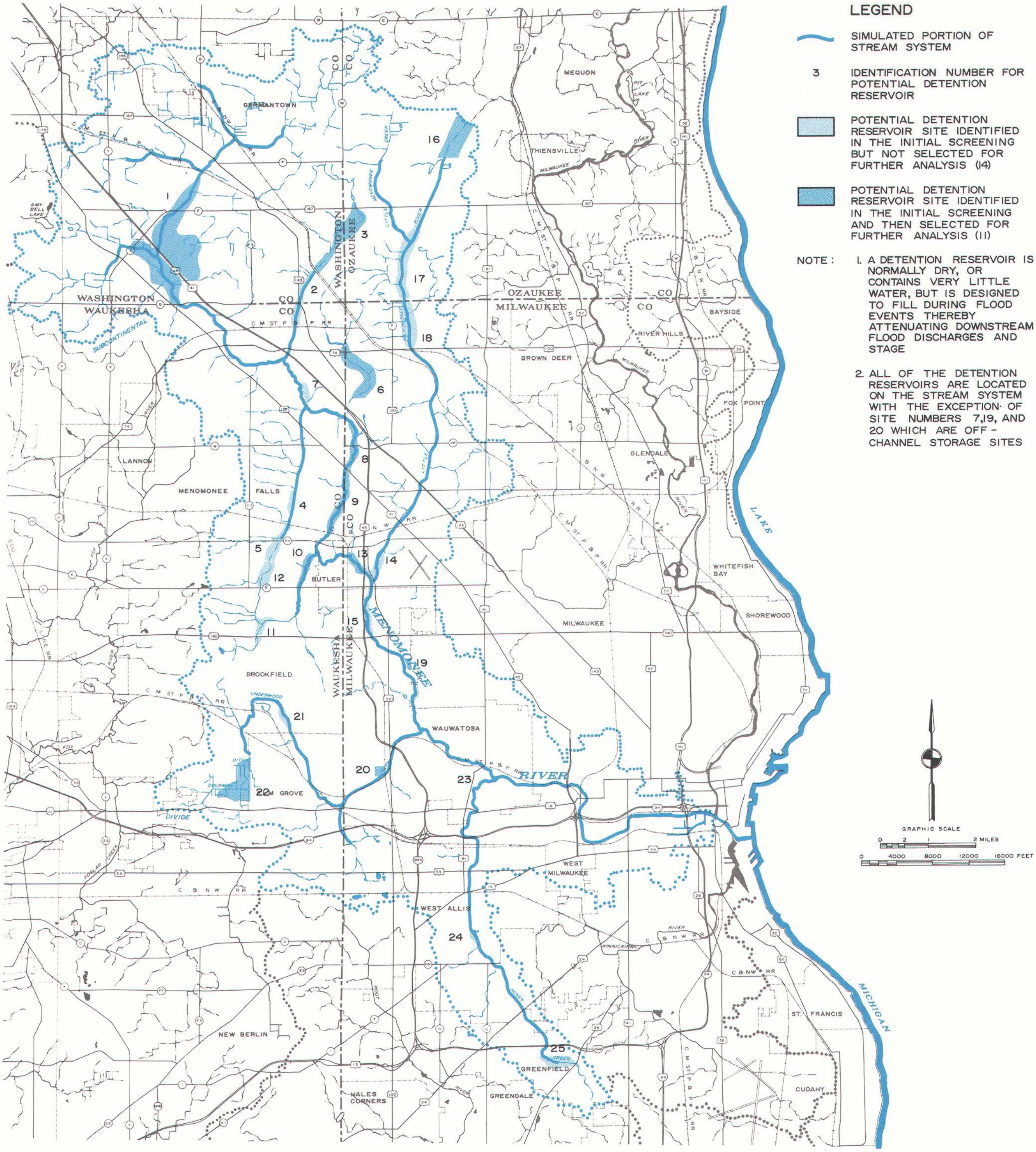
Evaluation of Selected Surface Storage Sites

The 11 remaining floodwater storage sites, which range in size from Site 9 on the Menomonee River in the Village of Menomonee Falls with a volume of about 600 acre-feet to Site 16 on the Little Menomonee River in the City of Mequon with a volume of about 5,900 acre-feet, were subjected to hydrologic-hydraulic and, in some cases, economic analysis in order to identify those individual

[5] *The potential surface storage sites include North Lake, an approximately 60-acre lake to be formed and developed by the Milwaukee County Park Commission in park lands along the Little Menomonee River between Brown Deer Road and the Milwaukee-Ozaukee County line. See: "North Lake Development," a report to the Milwaukee County Park Commission from the Harza Engineering Company, August 1971.*

Map 18

POTENTIAL FLOODWATER STORAGE SITES IN THE MENOMONEE RIVER WATERSHED



A total of 25 potential surface floodwater storage locations were identified and screened to determine their potential to provide, either singly or in various combinations, flood damage mitigation in the watershed. Based upon the screening of the sites, 11 were selected for further hydrologic, hydraulic, and economic analyses. In addition, the feasibility of storing floodwater in a mined storage chamber beneath the watershed was examined.

Source: SEWRPC.

Table 24

SUMMARY OF THE PRELIMINARY IDENTIFICATION AND INITIAL EVALUATION OF POTENTIAL FLOODWATER STORAGE SITES IN THE MENOMONEE RIVER WATERSHED

Location							Impoundment Data at Approximate Maximum Flood Stage				Potential for Mitigation of Flood Problems		
Number	Name	Stream	County	City, Village, or Town	River Mile	Dam Street, Highway, or Other Description	Tributary Area (Mi^2)	Stage (feet-msl)	Surface Area (Acres)	Volume (Acre-Feet)	Number of Flood-prone Reaches Downstream of the Site	Is it likely that the site will yield significant flood damage reduction in one or more downstream reaches?	Retain site for Hydrologic-Hydraulic Analysis?
1	Germantown	Menomonee River	Washington	Village of Germantown	23.47	CTH Q	26.36	845.0	1,019	5,806	12	Yes	Yes
2	NXWC-Downstream	Nor-X-Way Channel	Waukesha and Washington	Village of Menomonee Falls	1.35	Chicago, Milwaukee, St. Paul & Pacific Railroad	3.74	780.0	39	180	11	No	No
3	NXWC-Upstream	Nor-X-Way Channel	Washington	Village of Germantown	2.08	Chicago, Milwaukee, St. Paul & Pacific Railroad	2.58	790.0	213	1,470	11	Yes	Yes
4	Lilly Creek-Downstream	Lilly Creek	Waukesha	Village of Menomonee Falls	1.83	Mill Road	2.77	774.0	--	--	10	No	No
5	Lilly Creek-Upstream	Lilly Creek	Waukesha	Village of Menomonee Falls	2.49	Chicago and Northwestern Railroad	1.77	780.0	112	--	11	No	No
6	Dretzka	Dretzka Creek	Milwaukee and Waukesha	City of Milwaukee		Bradley Road	3.27	750.0	194	801	7	Yes	Yes
7	Menomonee Falls Lagoon	Menomonee River	Waukesha	Village of Menomonee Falls	18.95	Menomonee Falls Wastewater Treatment Plant	38.06	--	--	--	8	No	No
8	West Granville	Menomonee River	Milwaukee	City of Milwaukee	16.65	STH 175	49.40	740.0	145	635	7	Yes	Yes
9	Carmen	Menomonee River	Waukesha	Village of Menomonee Falls	15.00	Chicago and Northwestern Railroad	51.06	734.0	102	606	7	Yes	Yes
10	Butler Ditch-Downstream	Butler Ditch	Waukesha	Village of Menomonee Falls	0.00	Just upstream of the confluence with Menomonee River	5.05	780.0	242	1,793	7	Yes	Yes
11	Woodland	Butler Ditch	Waukesha	City of Brookfield	2.49	Just downstream of Capitol Drive	3.06	765.0	101	364	7	Yes[a]	No
12	Butler Ditch-Upstream	Butler Ditch	Waukesha	Village of Menomonee Falls	3.40	Lisbon Avenue	0.76	780.0	112	--	7	No	No
13	Zoo Freeway	Menomonee River	Milwaukee and Waukesha	City of Milwaukee	12.88	USH 45	58.00	714.0	95	694	6	Yes	Yes
14	Hampton	Menomonee River	Milwaukee	City of Milwaukee	12.52	Hampton Avenue	81.62	700.0	101	191	6	No	No
15	Currie	Menomonee River	Milwaukee	City of Wauwatosa	11.20	Capitol Drive	82.47	700.0	72	384	6	No	No
16	Mequon-Upstream	Little Menomonee River	Ozaukee	City of Mequon	10.18	Freistadt Road	1.40	755.0	381	5,861	9	Yes	Yes
17	Mequon-Downstream	Little Menomonee River	Ozaukee	City of Mequon	6.95	CTH Q	10.56	725.0	--	--	6	No	No
18	North Lake Reservoir	Little Menomone River	Milwaukee	City of Milwaukee	5.88	Brown Deer Road	11.80	718.6	306	842	6	No	No
19	Hartung Quarry	Menomonee River	Milwaukee	City of Milwaukee	10.15	Menomonee River Parkway Drive	85.57	690.0	20	1,950	5	Yes	Yes
20	Tosa Gravel Pit	Underwood Creek	Milwaukee	City of Wauwatosa	1.35	Watertown Plank Road	17.18	--	47	700	4	Yes	Yes
21	North Avenue	Underwood Creek	Waukesha	City of Brookfield	4.82	North Avenue	7.55	750.0	--	--	6	No	No
22	Gebhardt	Dousman Ditch	Waukesha	City of Brookfield	0.63	Gebhardt Road	3.78	830.0	376	1,366	9	Yes	Yes
23	Honey Creek	Honey Creek	Milwaukee	City of West Allis	0.06	Honey Creek Parkway	10.82	680.0	54	968	2	No	No
24	McCarty	Honey Creek	Milwaukee	City of West Allis	4.32	McCarty Park	5.76	730.0	--	--	2	No	No
25	Layton	Honey Creek	Milwaukee	City of Greenfield	7.78	Layton Avenue	1.41	760.0	--	--	2	No	No

[a] *Omitted from further consideration because of high land acquisition and development costs relative to probable flood damage reduction benefits.*

Source: SEWRPC.

sites, or combinations of sites, that could be expected to substantially reduce flood stages and, therefore, damages in some or all of the flood-prone reaches of the watershed. This phase of the analysis was initiated by examining the simulated 35-year flood flow series for the watershed under year 2000 plan conditions in order to determine the three largest watershedwide flood flow events and to identify the meteorological conditions that could be expected to produce these flood flows. As might be expected, the causative meteorological events were found to be the same as those that produced the three major historic flood events that were identified in the historic flood survey: June 1940, September 1972, and April 1973. The analysis thus indicated that, if the weather conditions similar to those represented by the historic meteorological data series for the 35-year period from 1940 through 1974 were to occur in the watershed under year 2000 plan conditions, the three largest watershedwide flood events would be produced by meteorological conditions similar to those which produced the June 1940, September 1972, and April 1973 floods.

Accordingly, the meteorological conditions which produced the three largest flood events of record were used in the hydrologic and hydraulic simulation model to test the individual performance of four larger reservoir sites which, based on size and relative location with respect to flood-prone reaches, were believed to have good potential for mitigating flood damages in those reaches. The purpose of this test was to determine to what extent flood flows could be expected to be reduced in those flood-prone reaches by the construction of single storage reservoirs, and to thereby identify those impoundments for which more detailed hydrologic, hydraulic, and economic studies were warranted. The four potential storage sites subjected to individual analysis were: Site 2 on the Menomonee River in the Village of Germantown lying immediately upstream of flood-prone reaches along the Menomonee River in the Village of Menomonee Falls; Site 16 on the Little Menomonee River in the City of Mequon lying immediately upstream of a flood-prone reach along the Little Menomonee River in the City of Mequon; Site 19—Hartung Quarry—

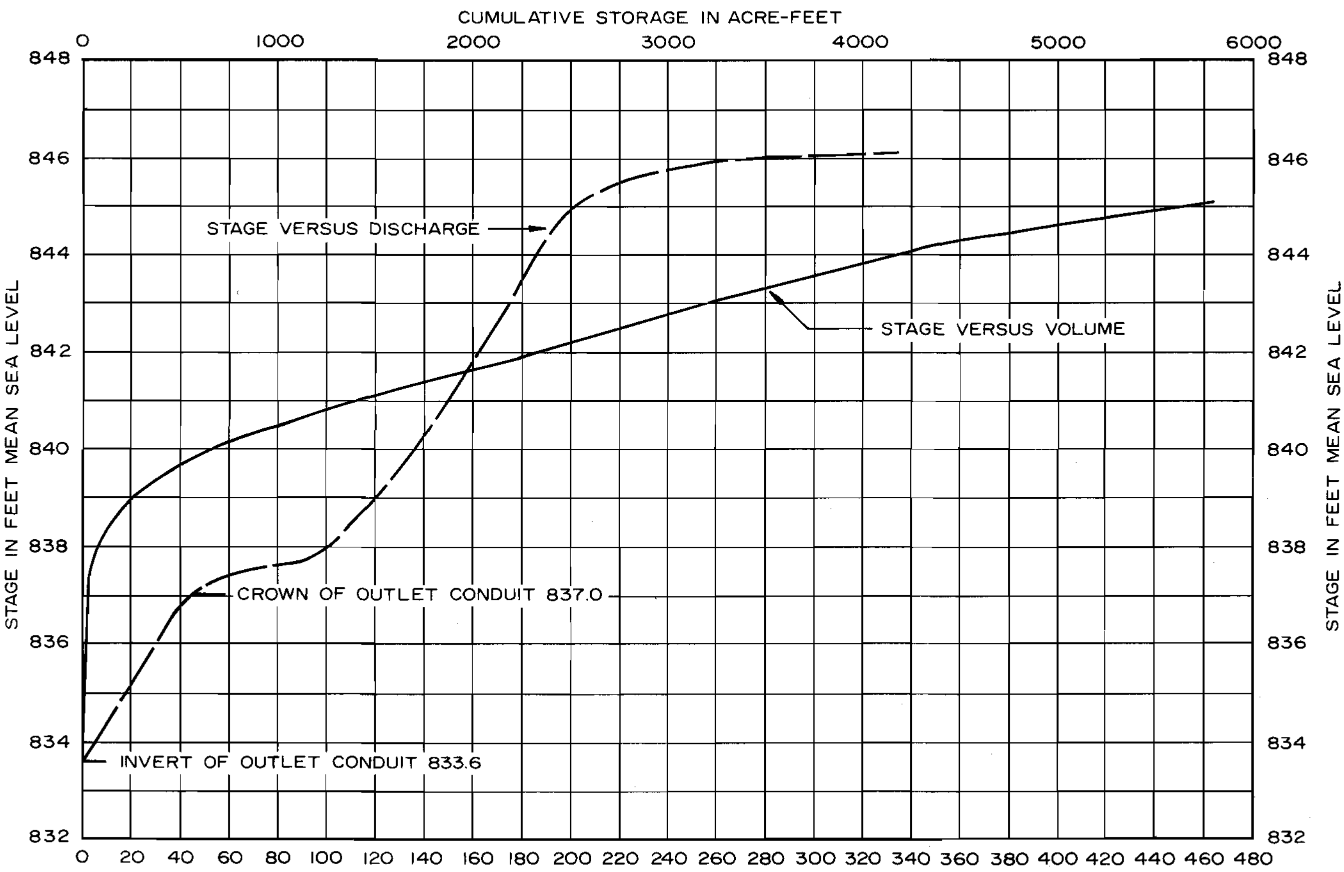
lying adjacent to the Menomonee River in the City of Milwaukee and immediately upstream of flood-prone reaches along the Menomonee River in the City of Wauwatosa; and Site 22 on Dousman Ditch in the City of Brookfield lying immediately upstream of flood-prone reaches along Underwood Creek in the City of Brookfield and the Village of Elm Grove.

The analysis of the potential effects of each of the four individual detention reservoirs was followed by a hydrologic-hydraulic simulation model study—again using the meteorological conditions corresponding to the three largest flood events—of a watershedwide storage system composed of all eleven potential impoundments. The objective of this analysis was to determine if the integrated operation of all 11 detention reservoirs was a technically feasible means of abating flood problems in the lower reaches of the Menomonee River watershed particularly along the Menomonee River in the Cities of Wauwatosa and Milwaukee.

Each of the 11 potential storage sites was represented in simulation model by a stage-storage-discharge relationship. The stage-storage-discharge relationship for Site 1 on the Menomonee River in the Village of Germantown, which is graphically depicted in Figure 12, is similar to those developed for each of the potential detention reservoir locations. These relationships reflect the topography of the site—in the form of cumulative storage volume as a function of stage or pool elevation—and the hydraulic characteristics of the outlet control structure—in the form of total discharge through and over the structure as a function of stage. The outlet structure for each of the nine on-channel storage sites was designed as an earthen embankment or concrete structure with a small conduit in its base at channel grade to pass low flows and to provide for gravity drainage of stored water after the occurrence of a flood event. The upstream end of the outlet structure conduit would be provided with a trash rack for safety purposes and to minimize blockage by ice and buoyant debris carried to the structure by the floodwaters. It would

Figure 12

STAGE-STORAGE-DISCHARGE RELATIONSHIP FOR POTENTIAL DETENTION RESERVOIR NO. 1 IN THE MENOMONEE RIVER WATERSHED



NOTE:
1. POTENTIAL RESERVOIR No. 1 IS LOCATED IN THE VILLAGE OF GERMANTOWN ON THE MENOMONEE RIVER AT THE WASHINGTON-WAUKESHA COUNTY LINE.
2. THE OUTLET STRUCTURE CONSISTS OF A CONDUIT BENEATH COUNTY LINE ROAD (CTH Q).

Source: SEWRPC.

be necessary to conduct a careful inspection and maintenance program to assure that the detention reservoir outlet works would always function at their design hydraulic capacity. In addition, an overflow spillway was provided to permit the safe passage of floodwater after the storage capacity of the detention reservoir was exceeded. For preliminary design purposes, the conduit through the base of each structure was sized so as to pass a two-year recurrence interval discharge under year 2000 plan conditions at a pool elevation coincident with the spillway crest. Such small conduit sizes were selected to permit maximum utilization of the available storage volume during major floods. Based on initial model runs, the conduits through the bases of five of the outlet structures—sites 1, 3, 10, 16, and 22—were reduced even further in size inasmuch as the storage impoundments at those locations were not filled by the design flood events. In the case of the two off-channel detention sites, it was assumed that a diversion structure would be provided on the adjacent channel that would permit diverting sufficient flow so as to approximately fill the available storage volume during the passage of the flood event.

Site One on the Menomonee River in the Village of Germantown: The first of the four sample reservoir sites considered was Site One located on the Menomonee River in the Village of Germantown. This 5,800 acre-foot detention reservoir would be formed by an earthen embankment located on the Menomonee River in the Village of Germantown at River Mile 23.47. It would thus be located immediately above flood-prone reaches of the Menomonee River in the Village of Menomonee Falls and, therefore, would have potential to abate flood problems in that Village. The hydrologic effect of this site is illustrated in Figure 13 which depicts flood flow hydrographs for the Menomonee River at Main Street (STH 74 and River Mile 21.93) and immediately upstream of the confluence with Nor-X-Way Channel (River Mile 20.31) in the Village of Menomonee Falls as those hydrographs would occur in response to the meteorological events which produced the April 1973 flood occurring under year 2000 plan conditions with and without the presence of the detention reservoir. The temporary impoundment of the flood flows could be expected to reduce the peak discharge of the Menomonee River at Main Street from about 530 cfs to about 350 cfs, a 35 percent reduction. At the confluence with the Nor-X-Way Channel, the peak discharge would be reduced from about 595 cfs to 575 cfs, a reduction of only 3 percent. The absolute and percent reduction in peak flood discharge at the downstream location is considerably less than that at the upstream location because of the dominant influence of the local lateral inflow to the Menomonee River between those two sites. The impact of lateral inflow at the downstream location is clearly evident on Figure 13 which shows a bimodal hydrographs, that is, hydrographs having two peak flows with the first peak representing the early arrival of local runoff and the second peak reflecting the later arrival of upstream runoff. While upstream storage effects an appreciable increase in the second peak discharge—which is associated with upstream runoff—it has no significant impact on the first, or local, peak. Farther downstream at the point where the Menomonee River flows from the Village of Menomonee Falls into the City of Milwaukee (River Mile 17.95), no appreciable decrease in peak flood flow would be expected.

Based on this hydrologic-hydraulic evaluation, it was concluded that a detention reservoir on the Menomonee River in the Village of Germantown would not offer significant flood relief to flood-prone lands along the Menomonee River in the Village of Menomonee Falls. Therefore, additional hydrologic-hydraulic analyses were not considered warranted, and Site 1 was eliminated from further consideration as a single floodwater storage reservoir.

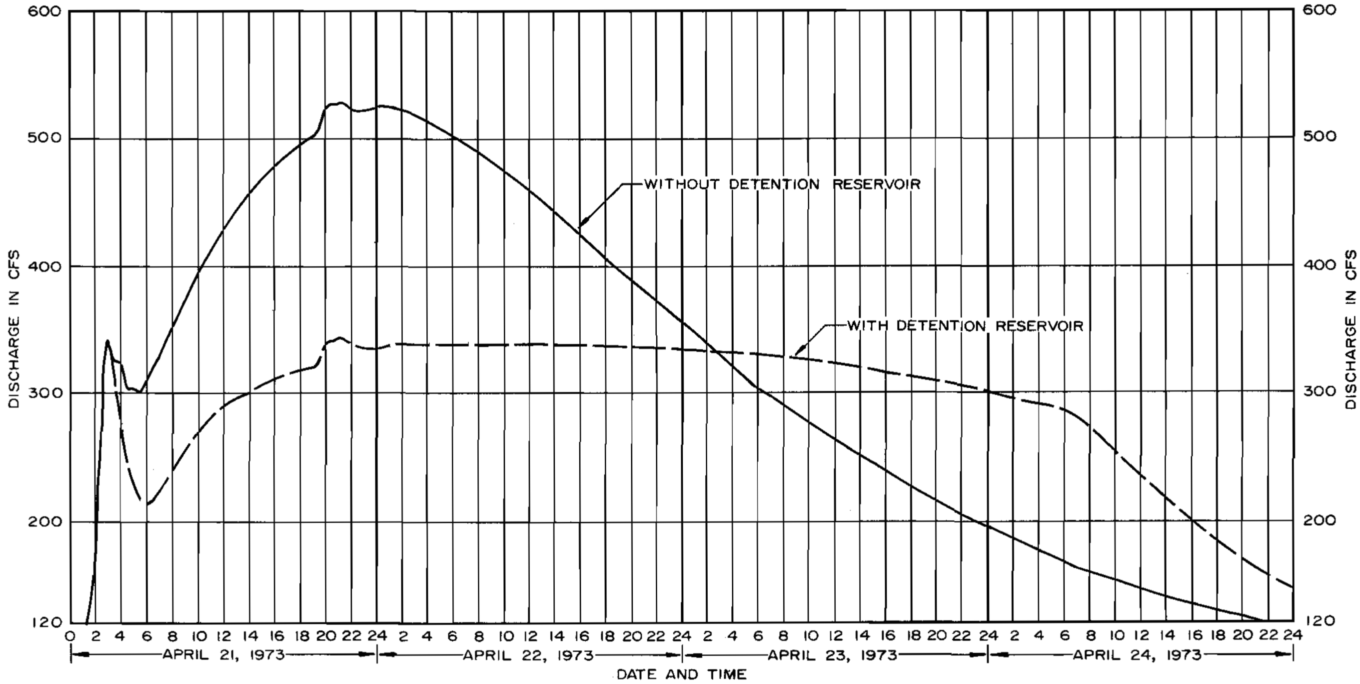
Site 16 on the Little Menomonee River in the City of Mequon: The second of the four sample reservoir sites considered was Site 16 located on the Little Menomonee River in the City of Mequon. A 5,860 acre-foot detention reservoir could be formed by an earthen embankment located at the Freistadt Road crossing of the Little Menomonee River in the City of Mequon at River Mile 10.18. It would be located immediately above a flood-prone reach in the City of Mequon and, therefore, would have potential to abate flood problems in that City.

For purposes of the analyses, the detention reservoir was assumed to capture essentially all of the direct runoff from the drainage area of the Little Menomonee River tributary to Freistadt Road. Therefore, the residual flow that would pass through the flood-prone reach would consist solely of the direct runoff contributed by the land surface downstream of Freistadt Road. Under a combination of the meteorological events which produced the April 19, 1973, flood and year 2000 plan land use-floodland development conditions, this detention reservoir could be expected to reduce the peak discharge near the upstream end of the flood-prone reach at River Mile 9.69 from about 100 cfs to about 42 cfs, a 58 percent reduction. The reservoir could also be expected to reduce the peak discharge of the Little Menomonee River immediately above its confluence with Little Menomonee Creek, River Mile 8.23, from about 120 cfs to approximately 90 cfs, a 24 percent reduction. The marked decrease in the reduction in flood flow with distance downstream is due to the influence of lateral inflow to the stream system downstream of the potential reservoir site. Assuming that the meteorological events which produced the September 1972 flood were to occur in the upper reaches of the Little Menomonee River subwatershed under year 2000 plan conditions, the detention reservoir could be expected to reduce the peak flood discharge at the upstream end of the flood-prone reach from about 123 cfs to about 60 cfs, a 51 percent reduction. At its confluence with the Little Menomonee Creek, the peak flood on the Little Menomonee River could be expected to be reduced from about 113 cfs to about 111 cfs, only a 2 percent reduction. Assuming that the meteorological events which produced the June 1940 flood were to occur under year 2000 plan conditions, a detention reservoir on the Little Menomonee River at Freistadt Road could be expected to reduce the peak flood discharge at the upstream end of the flood-prone reach in the City of Mequon from about 159 cfs to about 62 cfs, a 61 percent reduction.

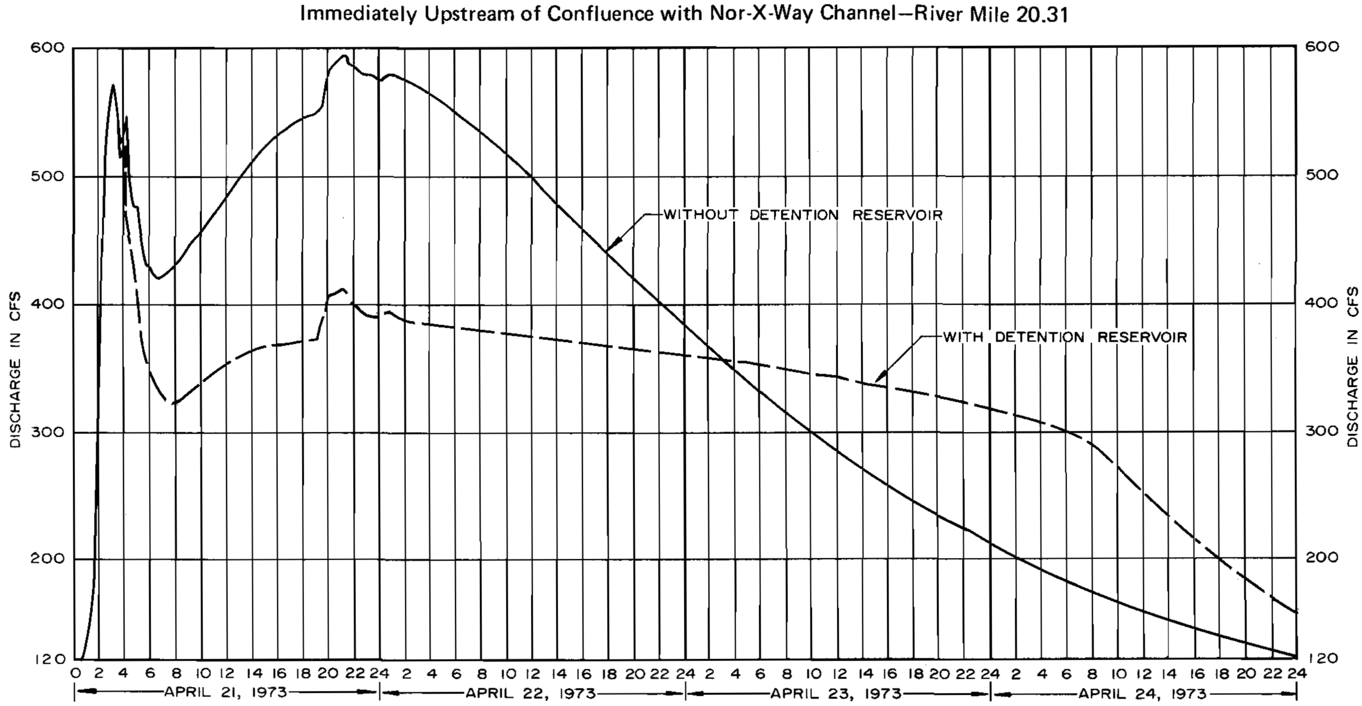
Figure 13

FLOOD FLOW HYDROGRAPHS ON THE MENOMONEE RIVER IN THE VILLAGE OF MENOMONEE FALLS WITH AND WITHOUT AN UPSTREAM DETENTION RESERVOIR

At STH 74 (Main Street)—River Mile 21.93



Immediately Upstream of Confluence with Nor-X-Way Channel—River Mile 20.31



NOTE:
1. HYDROGRAPHS ARE FOR THE METEOROLOGICAL EVENTS RESPONSIBLE FOR THE APRIL 21, 1973 FLOOD SUPERIMPOSED ON YEAR 2000 PLAN CONDITIONS.
2. THE UPSTREAM DETENTION RESERVOIR IS THE POTENTIAL 5806 ACRE-FOOT IMPOUNDMENT ON THE MENOMONEE RIVER IN THE VILLAGE OF GERMANTOWN. THE OUTLET CONTROL STRUCTURE WOULD BE AT RIVER MILE 23.47 ON THE WASHINGTON-WAUKESHA COUNTY LINE.

Source: SEWRPC.

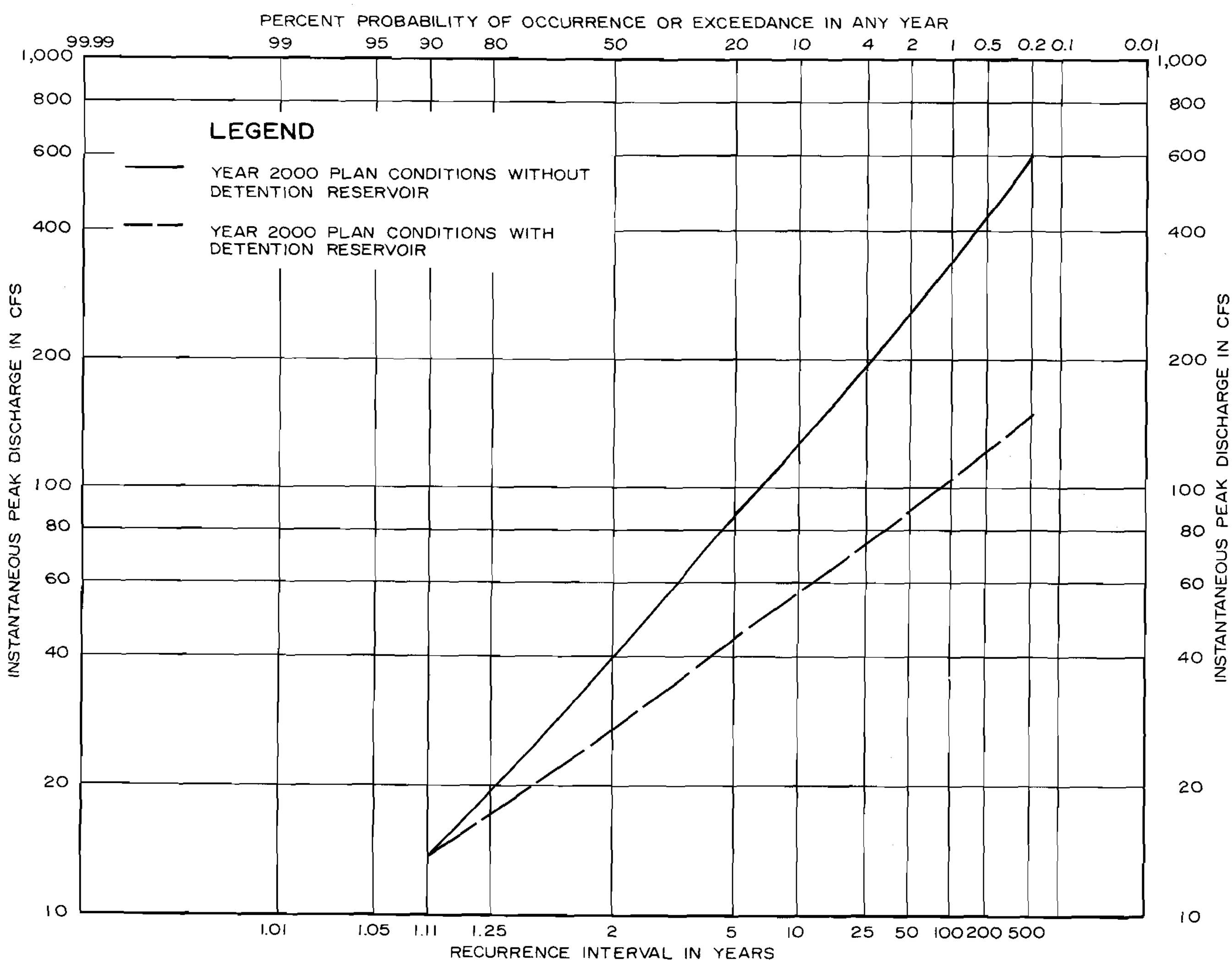
Downstream, just above its confluence with Little Menomonee Creek, the peak flood discharge on the Little Menomonee River could be expected to be reduced from about 162 cfs to about 115 cfs, a reduction of 29 percent.

Based on these analyses of the hydrologic-hydraulic behavior of this detention reservoir, which indicated that an impoundment located at the Freistadt Road could be expected to substantially reduce flood discharges through the flood-prone reach immediately downstream in the City of Mequon, further simulation studies were conducted. The objective of these analyses, which included additional hydrologic-hydraulic studies as well as economic analyses, was to determine the likely reduction in average annual monetary flood risks that could be achieved through the construction of this impoundment.

The flood flow simulation model was applied to that portion of the Little Menomonee River subwatershed tributary to the City of Mequon flood-prone reach using the entire available meteorological data base—consisting of 35 years of data—and year 2000 plan land use-floodland development conditions to further test the potential effects of a detention reservoir located at Freistadt Road. This simulation model application yielded flood flows within the flood-prone reach corresponding to the 35-year weather conditions. The flood flows were then used to develop a log Pearson Type III discharge-frequency relationship. Figure 14 shows the discharge-frequency relationships for the flood-prone reach with and without the upstream detention reservoir and indicates that the 100-year recurrence interval discharge could be reduced from about 300 cfs to 105 cfs as a result of construction of the detention reservoir.

Figure 14

DISCHARGE-FREQUENCY RELATIONSHIPS AT RIVER MILE 9.69 ON THE LITTLE MENOMONEE RIVER IN THE CITY OF MEQUON WITH AND WITHOUT AN UPSTREAM DETENTION RESERVOIR



Source: SEWRPC.

Hydraulic Submodel 2 was then used to compute flood stage profiles through the flood-prone reach for selected recurrence intervals. The resulting flood stage profiles were found to be significantly lower than those existing in the absence of the detention reservoir, with the decrease in stage associated with the 100-year recurrence interval discharge ranging from one to two feet. The resulting stage-probability information was then used in the model to compute average annual monetary risks.

Although topographic conditions and existing land use would permit development of a detention reservoir having a capacity of up to 5,860 acre-feet with a surface area of approximately 380 acres, the simulation studies indicate that only about 100 acre-feet of detention storage would be required to capture essentially all of the runoff generated by the 1.4 square mile tributary drainage area in response to the 35-year series of meteorological events. The necessary storage, plus two feet of freeboard, could be achieved with a detention reservoir, as shown on Map 19, covering about 86 acres of land at an elevation of 733.0 feet Mean Sea Level Datum. This land area was increased about 20 percent to 103 acres to provide for access to the site for maintenance purposes and to allow for refinement in the ultimate taking lines based upon consideration of real property boundary line locations.

The total capital cost of a detention reservoir at Site 16 is estimated at $41,700, consisting of $41,200 for land acquisition, $350 for construction of an outlet control structure at the existing culvert under Freistadt Road (CTH F), and $150 for constructing a small earthen embankment on the watershed divide at the upstream limits of the detention reservoir. The average annual cost corresponding to the $41,700 capital cost of the detention reservoir at a 6 percent interest rate and for a project life and amortization period of 50 years would be $2,645. Adding estimated operation and maintenance costs of $1,000 per year yields a total annual cost of $3,645.

The flood control benefits which could be expected to result from this expenditure would be the abatement of all of the flood damages in the residential area along the Little Menomonee River immediately north of Mequon Road that are directly attributable to the River therefore achieving an average annual benefit of $2,300. The resulting benefit-cost ratio would be about 0.63 and the annual excess of costs over benefits would be about $1,300. The analysis thus indicates that construction of a detention reservoir on the Little Menomonee River at Freistadt Road in the City of Mequon would be an economically unsound, although technically practicable, means for abating the Little Menomonee River flood problem in the residential area located immediately downstream of Freistadt Road.

Based on information obtained during the field surveys conducted in this area subsequent to the April 1973 flood and on an examination of topographic conditions, particularly natural drainage ways and roadside drainage swales, it appears as though the area also experiences inundation problems as a result of storm water runoff that originates on the high ground east of the residential area and flows through the area enroute to the Little Menomonee River. While construction of a detention reservoir upstream of the Little Menomonee River would eliminate some flooding from the River and may even provide for improved discharge of storm water from the residential area, some storm water problems are likely to remain.

<u>Site 19 Adjacent to the Menomonee River in the City of Milwaukee</u>: The third reservoir site considered, Site 19, consists of the Hartung Quarry, located in the City of Milwaukee adjacent to the Menomonee River at approximately River Mile 10.15. The quarry, which lies immediately above flood-prone reaches of the Menomonee River in the City of Wauwatosa, could provide 1,950 acre-feet of storage and has the potential to reduce flood damage in that City. Under a combination of the meteorological events which produced the April 1973 flood and year 2000 plan land use and floodland development conditions, flood water storage at Hartung Quarry could be expected to reduce the peak discharge of the Menomonee River at W. North Avenue, River Mile 8.33, immediately above the confluence with Underwood Creek, from about 6,200 cfs to about 4,300 cfs, a 31 percent reduction. The peak discharge at the N. 70th Street crossing of the Menomonee River in the City of Wauwatosa, River Mile 5.96, which is within that riverine area of the City of Wauwatosa experiencing the most serious flood problems, could be expected to be reduced from about 16,000 cfs to about 14,550 cfs, a reduction of only 9 percent.

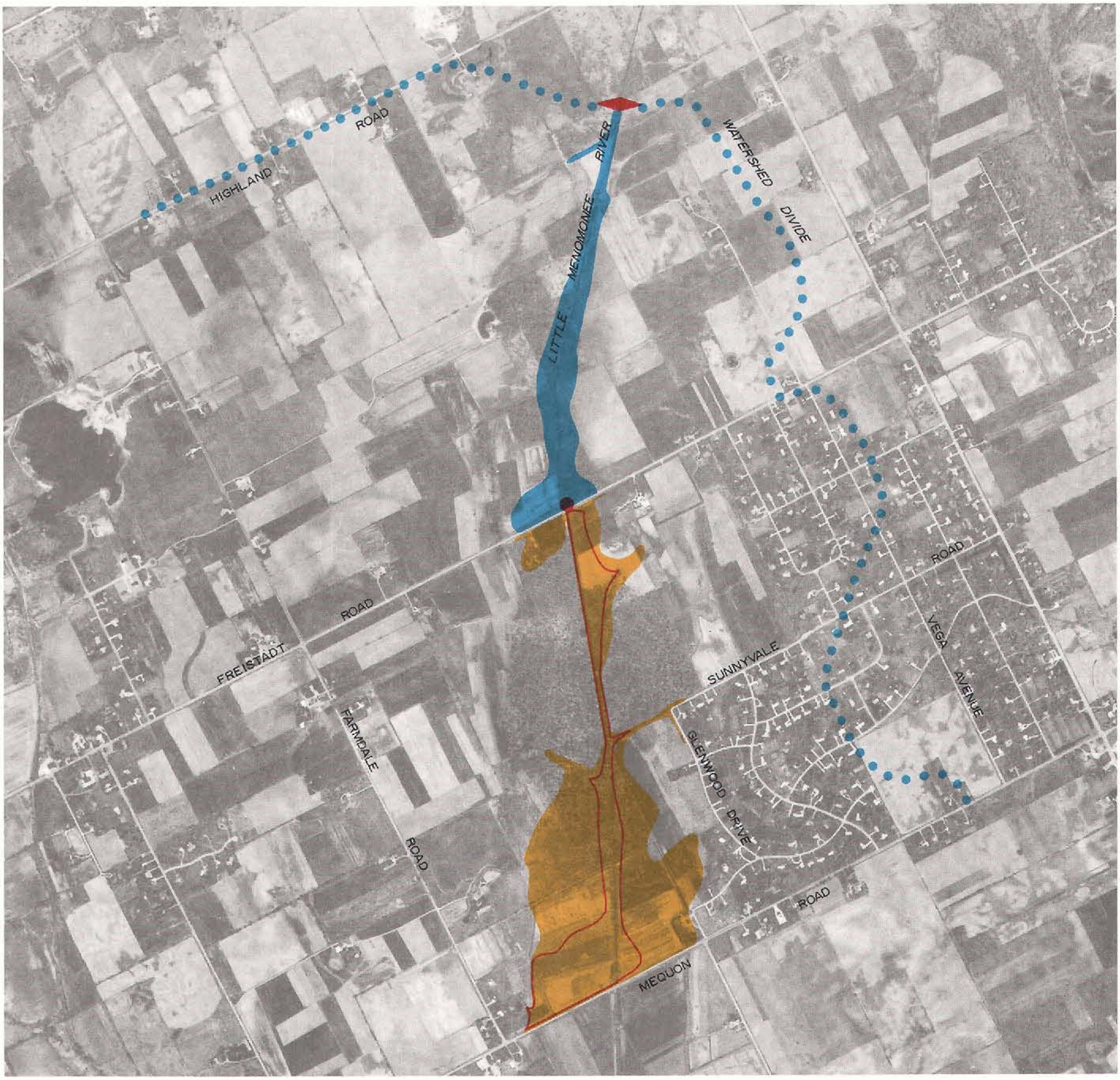
Based on this hydrologic-hydraulic evaluation, it was concluded that floodwater storage at Hartung Quarry would not offer significant flood relief to downstream flood-prone lands located along the Menomonee River in the Cities of Wauwatosa and Milwaukee. Therefore, additional hydrologic-hydraulic analyses were not considered warranted, and Site 19 was eliminated from further consideration as a single floodwater storage reservoir.

<u>Site 22 on Dousman Ditch in the City of Brookfield</u>: The fourth reservoir site considered was Site 22 located on the Dousman Ditch in the City of Brookfield. A 1,350 acre-foot detention reservoir could be formed by an earthen embankment located at Gebhardt Road, River Mile 0.63. It would be located immediately above the flood-prone reaches along Underwood Creek in the City of Brookfield, and the Village of Elm Grove, and, therefore, would have the potential of reducing flood damages in those communities.

Under the meteorological events which produced the April 1973 flood and year 2000 plan land use and floodland development conditions, this reservoir could be expected to reduce the peak flood discharge at North Avenue, River Mile 4.82, on the City of Brookfield-Village of Elm Grove boundary from about 1,830 cfs to about 1,070 cfs, a 42 percent reduction. It could also be expected to reduce the peak flood discharge on Underwood Creek at the Waukesha-Milwaukee County line, River Mile 2.53, from about 1,990 cfs to about 1,600 cfs, a 20 percent reduction. Assuming that the meteorological events which produced the September 1972 flood occurred in the watershed under year 2000 plan land use and floodland development conditions, the detention reservoir could be expected to reduce the peak flood discharge of Underwood Creek at

Map 19

DETENTION RESERVOIR AT SITE 16 ON THE LITTLE MENOMONEE RIVER AT FREISTADT ROAD IN THE CITY OF MEQUON



LEGEND

PROPOSED DETENTION RESERVOIR (STORAGE POOL ELEVATION 731.0 FEET MEAN SEA LEVEL)

PROPOSED EARTHEN EMBANKMENT ON WATERSHED DIVIDE (TOP OF EMBANKMENT AT ELEVATION 733.0 FEET MEAN SEA LEVEL)

PROPOSED OUTLET CONTROL STRUCTURE (SPILLWAY AT ELEVATION 731.0 FEET MEAN SEA LEVEL)

100-YEAR RECURRENCE INTERVAL FLOODLANDS WITHOUT DETENTION RESERVOIR

100-YEAR RECURRENCE INTERVAL FLOOD HAZARD LINE WITH DETENTION RESERVOIR

NOTE: A DETENTION RESERVOIR IS NORMALLY EMPTY BUT IS DESIGNED TO FILL DURING FLOOD EVENTS THEREBY ATENUATING DOWNSTREAM FLOOD DISCHARGE AND STAGE

GRAPHIC SCALE

0 500 1000 1500 2000 FEET

DATE OF PHOTOGRAPHY MAY 1975

A detention reservoir covering a site of approximately 100 acres was examined as an alternative means of resolving the flood problems experienced by residential development on the edges of the Little Menomonee River floodplain immediately upstream of Mequon Road. Analyses indicated that, although the detention reservoir was technically feasible, it would not be an economically sound means for abating the flood problem.

Source: SEWRPC.

North Avenue from about 725 cfs to about 420 cfs, a 42 percent reduction. It could also be expected to reduce the peak discharge on Underwood Creek at the Waukesha-Milwaukee County line from about 795 cfs to about 605 cfs, a 24 percent reduction. Assuming that the meteorological events which produced the June 1940 flood occurred under year 2000 plan land use and floodland development conditions, the detention reservoir could be expected to reduce the peak flood discharge on Underwood Creek at W. North Avenue from about 945 cfs to about 485 cfs, a 49 percent reduction. It could also be expected to reduce the peak flood discharge at the Waukesha-Milwaukee County line from about 1,000 cfs to about 735 cfs, a 27 percent reduction.

Based on this analysis, which indicated that an impoundment located at Site 22 could be expected to substantially reduce flood discharges through downstream flood-prone reaches in the City of Brookfield and the Village of Elm Grove, further simulation studies were conducted. The objective of these analyses, which included additional hydrologic-hydraulic studies as well as economic investigations, were to determine the reduction in average annual monetary flood risks along Underwood Creek in the City of Brookfield and the Village of Elm Grove.

The flood flow simulation model was applied to that portion of the Underwood Creek subwatershed west of the Waukesha-Milwaukee County line, using the complete available meteorological data base—consisting of 35 years of data—and year 2000 plan land use-floodland development conditions and assuming that a reservoir was constructed at Site 22. This simulation model application yielded flood flows corresponding to the 35-year period of meteorological conditions at selected points along Underwood Creek, including five locations within flood-prone reaches in the City of Brookfield and the Village of Elm Grove. The series of flood flows at these locations then was used to develop Log Pearson Type III discharge-frequency relationships. The model was then used to compute flood stage profiles through the flood-prone reaches for selected recurrence intervals. The resulting flood stage profiles were found to be significantly lower than those existing in the absence of the detention reservoir with the reduction in stage associated with the 100-year recurrence interval discharge ranging from zero to 10 feet with the largest decrease occurring in the City of Brookfield upstream of the Chicago, Milwaukee, St. Paul and Pacific Railroad bridge at River Mile 6.32. The detention reservoir could be expected to effect an approximately 2.5 foot decrease in the 100-year recurrence interval flood stage profile under year 2000 plan land use-floodland development conditions on Underwood Creek at W. North Avenue while the 100-year recurrence interval flood stage would be reduced by approximately 0.7 feet on Underwood Creek at the Waukesha-Milwaukee County line. The resulting stage-probability information was then used in the model to compute average annual monetary risks.

Although topographic conditions and existing land use would permit development of a detention reservoir having a capacity of up to 1,370 acre-feet with a surface area of approximately 376 acres, the simulation studies indicate that only about 215 acre-feet of detention storage would be required to control the runoff generated by the 3.78 square mile tributary drainage area in response to the 35-year series of meteorological events. The necessary storage, plus two feet of freeboard, could be achieved with a detention reservoir, as shown on Map 20, covering about 180 acres of land at an elevation of 827.6 feet Mean Sea Level Datum. This area was increased about 20 percent, to 216 acres, to provide for access to the site for maintenance purposes and to allow for refinement in the ultimate taking lines based upon consideration of real property line locations.

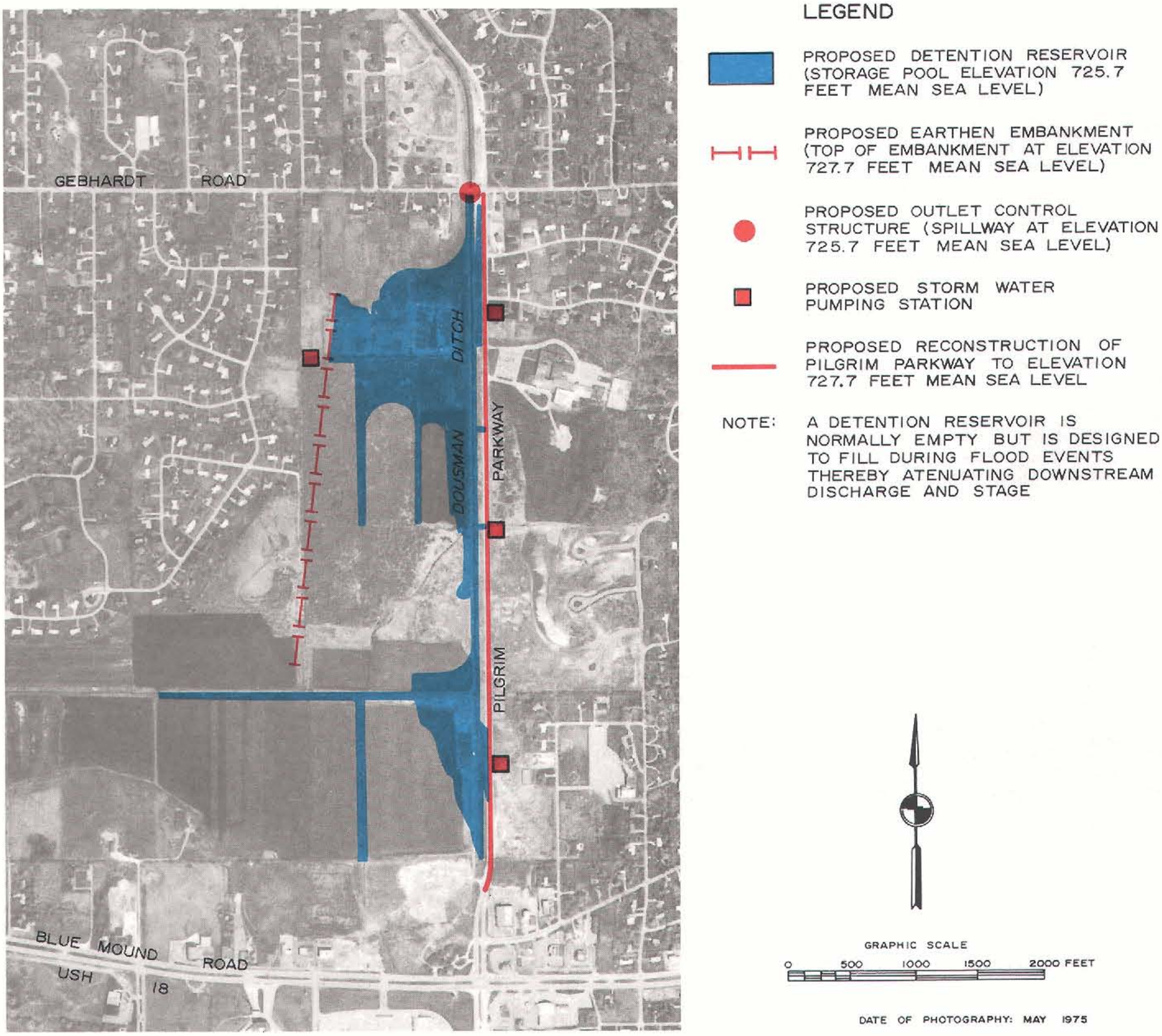
The total capital cost of the detention reservoir at Site 22 is estimated at $630,100, composed of $216,000 for land acquisition, $1,600 for construction of the outlet control structure at Gebhardt Road, $150,000 for elevating and improving Pilgrim Road (CTH YY) along the east edge of the reservoir, $2,500 for constructing an earthen embankment on the west side of the detention reservoir along the Indianwood Drive residential area, and $260,000 for construction of four backwater control and pumping facilities—three located along Pilgrim Parkway and one on Indianwood Drive. The average annual cost equivalent to the $630,100 capital cost of the detention reservoir at a 6 percent interest rate and for a project life and amortization period of 50 years would be $40,000. Adding estimated operation and maintenance costs of $6,200 per year yields a total annual cost of $46,200.

The flood control benefits which could be expected to result from this expenditure would be a 48 percent reduction in average annual flood damages—from $74,000 to $38,000—to the residential areas along Underwood Creek in the City of Brookfield and a 44 percent reduction in average annual flood damages—from $363,000 to $203,000—to the residential and commercial areas along Underwood Creek in the Village of Elm Grove. Thus the annual average benefit would approximate $36,000 in Brookfield and $160,000 in Elm Grove for a total of $196,000. The resulting benefit-cost ratio would be 4.2, and the annual excess of benefits over cost would be about $150,000. Thus a detention reservoir located on the Dousman Ditch at Gebhardt Road in the City of Brookfield is an economically sound, as well as technically practicable, means for abating part of the flood problem in downstream residential and commercial areas within the City of Brookfield and the Village of Elm Grove.

System of Surface Storage Sites: The above analyses of the four individual potential detention reservoirs were followed by a watershedwide simulation study utilizing the meteorological conditions responsible for the June 1940, September 1972, and April 1973 floods. The purpose of this study was to determine if the construction and integrated operation of a system of 11 detention reservoirs constituted a technically feasible means of abating flood problems in the lower reaches of the Menomonee River through the Cities of Wauwatosa and Milwaukee. The 11 sites comprising the system of surface storage would have a combined storage volume of about 21,700 acre-feet. This volume is approximately equivalent to three inches of

Map 20

DETENTION RESERVOIR AT SITE 22 ON DOUSMAN DITCH AT GEBHARDT ROAD IN THE CITY OF BROOKFIELD



A 215 acre flood detention reservoir on Dousman Ditch at Gebhardt Road in the City of Brookfield was examined as one alternative means of resolving existing and forecast flood problems along Underwood Creek in the City of Brookfield and the Village of Elm Grove. Hydrologic, hydraulic, and economic analyses indicated that the detention reservoir would substantially reduce flood discharges, flood stages, and flood damages along downstream flood-prone reaches. This detention reservoir, in combination with other structural and nonstructural measures, was recommended for inclusion in the watershed plan for resolution of the Elm Grove-Brookfield flooding problem.

Source: SEWRPC.

water over the watershed land surface and also approximates the amount of direct runoff from the watershed during the April 1973 flood—the maximum flood of record.

Under a combination of conditions consisting of meteorological events which produced the April 1973 flood and year 2000 plan land use and floodland development, the system of surface storage sites could be expected to reduce the peak discharge of the Menomonee River at North Avenue, River Mile 8.50, immediately above the confluence with Underwood Creek, from about 6,200 cfs to about 3,700 cfs, a 40 percent reduction, while the peak flood stage would be reduced by approximately 4.2 feet. At the N. 70th Street crossing of the Menomonee River in the City of Wauwatosa, River Mile 5.96, in a riverine area experiencing serious flood problems, the peak flood discharge could be expected to be reduced from about 16,000 cfs to about 11,050 cfs, a reduction of 31 percent, while the peak flood stage would be reduced by approximately 1.7 feet. The peak flood discharge at the Hawley Road Crossing of the Menomonee River in the City of Milwaukee (River Mile 5.15) which is also within a riverine area experiencing serious flood problems, could be expected to be reduced from about 16,250 cfs to about 11,600 cfs, a 29 percent reduction, while the peak flood stage would be reduced by approximately 2.7 feet. The above discharge reduction-stage reduction data demonstrate a common characteristic of floodland hydrology and hydraulics in that large percent reductions in major flood discharge are normally accompanied by only small absolute reductions in stage.

Under a combination of conditions consisting of the meteorological events which produced the September 1972 flood and year 2000 plan land use and floodland development, the system of surface storage sites could be expected to reduce the peak flood discharge of the Menomonee River at W. North Avenue, River Mile 8.50, from about 4,600 cfs to about 2,900 cfs, a 37 percent reduction. The peak flood discharge at the N. 70th Street crossing of the Menomonee River in the City of Wauwatosa, River Mile 5.96, could be expected to be reduced from about 10,100 cfs to about 7,550 cfs, a reduction of 25 percent. The peak flood discharge at Hawley Road crossing of the Menomonee River in the City of Milwaukee (River Mile 5.15) could be expected to be reduced from about 9,700 cfs to about 7,750 cfs, a 20 percent reduction.

Under a combination of conditions consisting of meteorological events which produced the June 1940 flood and year 2000 plan land use and floodland development, the system of surface storage sites could be expected to reduce the peak flood discharge of the Menomonee River at North Avenue, River Mile 8.50, from about 4,900 cfs to about 2,800 cfs, a 43 percent reduction. The peak flood discharge at the N. 70th Street crossing of the Menomonee River in the City of Wauwatosa, River Mile 5.96, could be expected to be reduced from about 11,700 cfs to about 8,000 cfs, a reduction of 32 percent. The peak discharge at the Hawley Road crossing of the Menomonee River in the City of Milwaukee, River Mile 5.15, could be expected to be reduced from about 12,350 cfs to about 8,950 cfs, a 27 percent reduction.

Based on this hydrologic-hydraulic evaluation, it was concluded that the flood water storage provided by a system of 11 surface storage sites would not offer significant flood relief to flood-prone lands located along the Menomonee River in the City of Wauwatosa and the City of Milwaukee. Such a storage system would achieve a peak flood discharge reduction of only about 30 percent along the Menomonee River reach from about N. 70th Street downstream to Hawley Road under the three selected meteorological events and future land use conditions. Therefore, additional hydrologic-hydraulic analyses were determined to be not warranted, and the system of surface storage sites was eliminated from further consideration as a structural floodland management measure.

Feasibility of Subsurface Storage

A preliminary assessment was made of the technical and economic feasibility of constructing mined storage chambers in the bedrock underlying the lower portions of the watershed and using these chambers for the temporary storage of floodwaters thereby providing protection to flood-prone reaches along Underwood Creek in the Cities of Brookfield and Wauwatosa and the Village of Elm Grove, along Honey Creek in the City of Wauwatosa, and along the Menomonee River in the Cities of Wauwatosa and Milwaukee. One large mined storage chamber could be constructed beneath the lower portion of the watershed with connections to flood-prone reaches by means of conduits, or a series of smaller mined storage chambers could be constructed at several locations throughout the lower portion of the watershed so as to afford protection to the above listed reaches. The mined storage chamber or chambers would receive flood waters from the stream system in the lower portion of the watershed during major flood events and then, subsequent to the passage of the flood, would be emptied by pumping the stored water back into the stream system, or by using the water for other purposes such as water supply or augmentation of low stream flows.

Initial evaluation of simulated flood flows indicated that a total storage capacity of about 7,500 acre-feet would be required in the lower portion of the watershed to substantially reduce the flood damages that may be expected to be incurred along Underwood Creek, Honey Creek, and the Lower Menomonee River during major flood events. Assuming a unit cost of $15.00 per cubic yard of mined storage, the total capital cost for subsurface storage would be $180 million. The corresponding average annual cost at a 6 percent interest rate and a project life and amortization period of 50 years—exclusive of operating and maintenance costs—would be $11.5 million. The maximum potential flood control benefits that could be attributed to this alternative would be the elimination of all damages along Underwood Creek, Honey Creek, and the Lower Menomonee River which are estimated to be an average of $945,800 per year under 2000 plan conditions. Thus, the benefit-cost ratio for the subsurface storage alternative would be about 0.08 and annual costs would exceed annual benefits by about $10.5 million, clearly indicating that this alternative would be economically unsound.

Other possibilities exist for the construction subsurface storage facilities within the Menomonee River watershed that would achieve some flood mitigation benefits such as in the Village of Menomonee Falls area. While these and other potential subsurface storage arrangements might be technically feasible, they were not examined further under the watershed planning program because it was apparent from the preliminary screening of the lower watershed subsurface storage alternative that other subsurface storage alternatives within the basin would be unsound economically by a wide margin.

FLOODWATER DIVERSION ALTERNATIVES

In the consideration of alternative structural flood control measures, it was recognized that Lake Michigan might provide a convenient discharge point for floodwaters diverted from within the Menomonee River watershed but that, while such a diversion may be technically feasible, it would probably not be economically sound. The preliminary screening of diversion possibilities also identified the possibility of diverting floodwaters from the Menomonee River watershed stream system down into the deep tunnel system which is one alternative recommended for abatement of the combined sewer overflow problem in the Milwaukee metropolitan area. Each of these two floodwater diversion possibilities—diversion to Lake Michigan and diversion to the deep tunnel system—were subjected to a preliminary examination and, as described below, were found to be technically feasible but economically unacceptable.

Diversion to Lake Michigan

In order to obtain a preliminary quantification of the economics of diversion to Lake Michigan, one potential diversion was subjected to preliminary technical and economic analyses. It was assumed that a gravity flow conduit would be constructed from the Menomonee River, immediately downstream of its confluence with the Little Menomonee River, beneath Hampton Avenue through portions of the City of Milwaukee, the City of Glendale, and the Village of Whitefish Bay, discharging to Lake Michigan at the foot of E. Hampton Avenue. The diversion conduit would have a total length of about 8.7 miles. The upstream invert would be at an elevation of about 680 feet above mean sea level datum and the downstream invert would be at an elevation of about 560 feet above mean sea level datum for a total drop, and therefore available hydraulic head, of 120 feet. The conduit would be tunneled through unconsolidated material and would be lined with concrete.

A design flow of 6,900 cfs was selected, approximately the entire 100-year recurrence interval flood discharge of the Menomonee River under year 2000 conditions at the point of diversion. Hydraulic calculations indicate that a conduit having a diameter of approximately 20 feet would be required to carry the design flow under gravity flow conditions using the available hydraulic head.

Assuming a unit cost of $1,500 per lineal foot of conduit, the total capital cost for the diversion conduit would be $69.0 million. The corresponding average annual cost at a 6 percent interest rate and a project life and amortization period of 50 years would be $4.4 million, excluding operation and maintenance costs. The maximum potential flood control benefits that could be anticipated from this alternative would be the elimination of all damages along the Menomonee River within the Cities of Wauwatosa and Milwaukee, damages estimated at an average of $504,900 per year under year 2000 plan conditions. The benefit-cost ratio for the diversion alternative would thus be about 0.11, clearly indicating that this alternative would be economically unsound. The alternative would have the additional disadvantage of discharging to Lake Michigan in the vicinity of the water supply intake for the Whitefish Bay-Fox Point-Glendale water supply systems, the intake being located about 1.5 miles to the north of E. Hampton Avenue.

There are other possibilities for the diversions to Lake Michigan from within the Menomonee River watershed that could achieve some flood mitigation benefits such as a diversion from Underwood Creek immediately upstream of the Village of Elm Grove and a diversion from the Menomonee River immediately upstream of the Village of Menomonee Falls. While these and other potential diversions to Lake Michigan might be technically feasible, they were not examined further under the watershed planning program because it was apparent from the preliminary screening of the Hampton Avenue diversion that other diversions within the basin would be economically unacceptable by a wide margin.

Diversion to the Deep Tunnel System

Another diversion possibility that was explored in a preliminary manner under the Menomonee River watershed planning program was the discharge of floodwaters to an expanded version of the deep tunnel system recommended in the Milwaukee River watershed plan. As described in detail in Chapter VII, Volume 1, of this report, the Menomonee River watershed combined sewer system is part of a large, contiguous 27 square mile combined sewer service area in the Milwaukee metropolitan area which, during significant rainfall and snowmelt events, discharges combined sewage to the Menomonee, Milwaukee, and Kinnickinnic Rivers and to Lake Michigan. The adopted Milwaukee River watershed plan recommends a combination deep tunnel, mined storage/flow through treatment alternative as the most cost-effective solution to the combined sewer overflow problem. The plan further recommends that a preliminary engineering study be undertaken to determine with greater precision and detail the configuration of the recommended system as required to serve the entire 27-mile combined sewer service area. As of 1976, a consulting firm retained by the Milwaukee-Metropolitan Sewerage Commission was midway through the recommended preliminary engineering study.

With respect to the Menomonee River watershed, the deep tunnel system would be constructed within the City of Milwaukee at a depth of 250 to 350 feet beneath the Menomonee River extending upstream six miles from the Milwaukee River to the Hawley Road crossing of the Menomonee River. The Menomonee River portion of the deep tunnel system would be constructed in dolomite bedrock, might be lined with concrete, and would have a diameter ranging from 8.5 feet at the downstream end to 6.0 feet at the upstream end.

Assuming that a commitment were made to construct the Menomonee River segment of the deep tunnel, it could provide part of a system whereby floodwaters could be diverted from flood-prone reaches in the Lower Menomonee River, conveyed through the deep tunnel to the mined storage chamber provided beneath the Milwaukee Harbor, and subsequently pumped from that storage reservoir and discharged to Lake Michigan. The cost of such a flood control measure would be the incremental cost associated with increasing the capacity of the recommended deep tunnel system so as to facilitate the capture, conveyance, and storage of floodwaters from the Menomonee River watershed in excess of that from the combined sewer service area tributary to the Menomonee River. More specifically, these incremental costs may include the costs of increasing the length of the deep tunnel beneath the Menomonee River so as to extend it farther upstream into the watershed, enlarging the diameter of the deep tunnel beneath the Menomonee River so as to increase its conveyance capacity, increasing the volume of the mined storage chamber beneath the Milwaukee Harbor so as to permit the storage of additional floodwaters and, finally, increasing the capacity for pumping water from the mined storage chamber and treating it prior to discharge to Lake Michigan.

The alternative of diverting Menomonee River watershed floodwaters to the deep tunnel system was subjected to an initial analysis consisting of a determination of the hydraulic consequences of extending the recommended Menomonee River deep tunnel from its terminus at Hawley Road upstream a distance of 1.4 miles to the Harwood Avenue crossing of the Menomonee River in the Old Village area of the City of Wauwatosa. This upstream tunnel terminus was selected since a major diversion of floodwaters at this location could result in a significant reduction in inundation and damages to downstream Menomonee River floodlands in the City of Wauwatosa.

This hydraulic analysis of the extended deep tunnel system indicated that if the entire facility were devoted to carrying floodwaters, that is, if there would be no local contribution of storm water runoff or combined sewage downstream of Harwood Avenue, the capacity of the deep tunnel would be only 600 cubic feet per second, relatively small compared to the 100-year discharge at Harwood Avenue of 12,600 cfs under year 2000 plan conditions. Therefore, a simple extension of the recommended deep tunnel beneath the Menomonee River would not constitute a technically feasible flood control alternative for the Menomonee River watershed.

The above initial analysis was followed by one in which the objective was to determine the technical and economic feasibility of a 7.4-mile-long deep tunnel needed to convey the 100-year discharge beneath the Menomonee River from Harwood Avenue downstream to mined storage chamber beneath the Harbor. Hydraulic computations indicated that an approximately 20-foot diameter conduit would be required. Assuming a unit cost of $1,500 per lineal foot of conduit, the total capital cost for the extended and expanded deep tunnel beneath the Menomonee River would be about $59 million. This is approximately $42 million in excess of the estimated $17 million capital cost of the recommended 6.0- to 8.5-foot diameter, 6.0-mile-long conduit between the Harbor and Hawley Road based on an estimated unit cost for the latter of $550 per lineal foot. The average annual cost corresponding to the $42 million incremental capital cost of the extended and expanded deep tunnel at 6 percent interest rate and for a project life and amortization period of 50 years would be $2.6 million exclusive of operating and maintenance costs.

The maximum potential flood control benefits which could be expected to result from this expenditure would be elimination of all damages along the Menomonee River within the City of Wauwatosa downstream of Harwood Avenue, estimated to be an average of $330,900 per year under 2000 land use plan conditions. Therefore, considering only the capital costs of the tunnel, the benefit-cost ratio for the alternative employing an extended and enlarged deep tunnel beneath the Menomonee River would be about 0.13 and the annual excess of costs over benefits is $2,269,000, clearly indicating that this alternative would be economically unsound.

There are other possibilities for diversions to Lake Michigan via an extended and enlarged tunnel system beneath the Menomonee River. While these potential diversions to Lake Michigan might be technically feasible, they were not examined further under the watershed planning program because it was apparent from the preliminary screening of the above diversion that other diversions from within the basin to Lake Michigan would be economically unacceptable by a wide margin.

ALTERNATIVE FLOODLAND MANAGEMENT PLAN ELEMENTS FOR INDIVIDUAL COMMUNITIES

In addition to examining structural alternatives—floodwater storage and floodwater diversion—which would have the potential of mitigating flood problems in several communities and in many flood-prone reaches, the watershed study also included an investigation of the potential for employing one or more primarily structural measures on a community-by-community basis in those riverine areas experiencing the most severe flood problems. The communities identified for inclusion in this analysis were the Village of Elm Grove, the City of Brookfield, the Village of Menomonee Falls, the City of Wauwatosa, the City of Mequon, and the City of Milwaukee, with the selection of communities being based on the earlier selection of river reaches requiring detailed assessment of floodland management measures. The floodland management measures examined for each of the above communities included floodproofing and removal of structures, channel modification, dike and floodwall construction, and bridge and culvert alteration or replacement. The results of these analyses are presented below on a community-by-community basis.

The Village of Elm Grove

The Flood Problem: As shown on Map 15, the Village of Elm Grove contains five flood-prone reaches which include the entire 2.29-mile-long portion of Underwood Creek lying within the Village.

For the Village as a whole, average annual monetary flood risks attributable to both primary and secondary flooding under existing conditions are estimated at about $213,800, whereas the average annual monetary flood risks under year 2000 land use and floodland development conditions are estimated at about $362,800, a 70 percent increase over existing conditions. It should be emphasized that the increase in average annual monetary damages under year 2000 plan conditions is solely attributed to anticipated changes in upstream land use development in the watershed inasmuch as the analysis presumes that no new flood-prone structures would be constructed in the Village of Elm Grove. As discussed earlier in this chapter, complete development of the floodland and nonfloodland portions of the tributary area could be expected to result in an approximately two-fold increase in average annual monetary flood risks and, if additional flood-prone development were permitted along Underwood Creek in the Village of Elm Grove, even higher monetary risks would be incurred. As a result of direct and indirect flood damages associated with Underwood Creek flooding, the Village may be expected to incur $1.36 million in flood damages during a 100-year recurrence interval flood under existing conditions, whereas the 10- and 100-year recurrence interval flood damages under year 2000 plan conditions could be expected to approximate $0.73 million and $1.51 million, respectively.

Floodproofing and Removal of Structures: A floodproofing and removal alternative was developed and analyzed to determine if such a structure-by-structure approach would be a technically, economically, and environmentally acceptable solution to the flood problem in the Village. For purposes of this analysis, the 100-year recurrence interval event under year 2000 plan condition was used as a basis for determining how many flood-prone structures would have to be removed and the number that would have to be floodproofed.

In the case of residential structures in the primary flooding zone, floodproofing was assumed to be feasible if the design flood stage was below the first floor elevation and structure removal was assumed to be required if the design flood stage was at or above the first flood elevation. Floodproofing was assumed to be feasible for all nonresidential structures within the primary flooding zone irrespective of flood stage, with the floodproofing cost for stages above the first floor being a function of the distance between the flood stage and the first floor elevation. With respect to structures located in the secondary flooding zone, that is, outside of but immediately adjacent to the 100-year recurrence interval floodlands, it was assumed that floodproofing would be applied to those structures with basement floors below the elevation of the design flood stage. The total floodproofing cost so computed for the secondary flooding zone was then reduced by a factor ranging from 0.50 to 0.90 to reflect the fact that not all buildings in that zone with basement floors set at an elevation below the design flood stage would in fact incur secondary flooding. The factors assigned to each flood-prone reach were the same as that used to compute flood damage in the secondary zone. Chapter VIII, Volume 1, of this report contains a complete discussion of the problems associated with the computation of flood damages in the secondary flooding zone and the manner in which that problem was resolved. As shown on Map 21, the analyses indicated that about 19 structures would have to removed from the 100-year recurrence interval floodlands under this alternative and a total of about 181 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damage to private residences and commercial structures within the Village of Elm Grove would be virtually eliminated by the floodproofing and removal. Table 25 sets forth the approximate number of structures to be floodproofed and removed and also summarizes the estimated costs and benefits.

Assuming that the aforementioned structure floodproofing and removal measures would be fully implemented and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the equivalent average annual cost is estimated at about $118,800, consisting entirely of the amortization of the $1.87 million capital cost—$0.58 miilion for floodproofing and $1.29 million for removal. The average annual flood abatement benefit is estimated at about $362,800, yielding a benefit-cost ratio of 3.05 and an excess of annual benefits over costs of about $244,000. Therefore, the structure floodproofing and removal plan element, as described herein, would be both technically and economically feasible within the Village of Elm Grove.

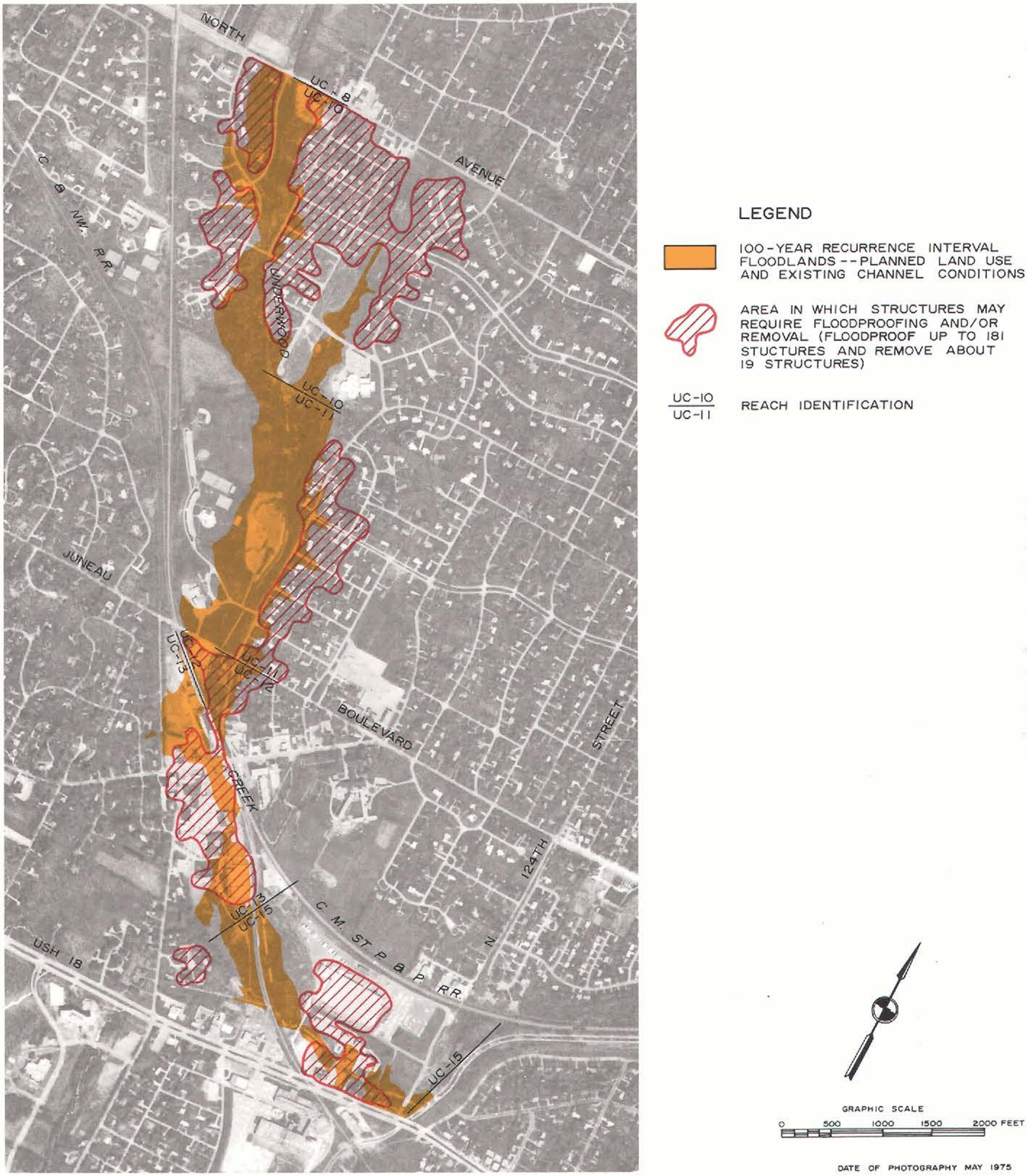
Channel Modifications: A major channel modification alternative was developed and analyzed for the lands subjected to flooding by Underwood Creek in the Village of Elm Grove in order to determine if such a structural measure would provide a technically feasible, economically sound, and environmentally acceptable solution to the existing and forecast flood problems. The proposed channel was designed to pass the 100-year recurrence interval flood discharges under year 2000 land use plan conditions without overtopping. A minor channel modification alternative also was investigated for a portion of Underwood Creek beginning in the Village of Elm Grove and extending upstream into the City of Brookfield.

Major Channelization: The major channelization alternative for Underwood Creek in the Village of Elm Grove is shown on Map 22. A schedule of the physical characteristics of the major channel modifications and the attendant costs and benefits is set forth in Table 25. Under this alternative, major channel improvements would be carried out over a total reach of 2.0 miles. The improved channel would be located along or near the alignment of Underwood Creek in the Village of Elm Grove extending from the Waukesha-Milwaukee County line at the downstream end of the Village to the Village of Elm Grove-City of Brookfield boundary (W. North Avenue) at the north end of the Village. The alignment of the proposed channel would follow the alignment of Underwood Creek except for an approximately three-quarter-mile-long reach at the east end of the Village where the new channel would be located as much as 1,000 feet north of the Underwood Creek paralleling the Chicago, Milwaukee, St. Paul, and Pacific Railroad right-of-way. This off-channel alignment was selected to minimize bridge and culvert reconstruction, to avoid passage through and disruption of the commercial area located along Bluemound Road, and to achieve a 0.15 mile reduction in the length of the channelization.

The bottom of the improved Underwood Creek Channel would, at its downstream end, match the grade of the existing channelized reach along the Milwaukee County portion of Underwood Creek. The channel bottom profile and the channel cross-sectional shape at the upstream end of the channelized reach would be designed so as to effect an acceptable transition from the major channelization within the Village of Elm Grove to the natural channel grade and shape in the City of Brookfield. Moving in a downstream direction, the channelization would lower the existing Underwood Creek channel grade by about 2.5 feet at Marcella Drive, about 6.5 feet at Juneau Boulevard, about 8.0 feet at Watertown Plank Road, and

Map 21

STRUCTURE FLOODPROOFING AND REMOVAL ALONG UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE



Structure floodproofing and removal were examined as one alternative means of resolving the existing and forecast flood problems along Underwood Creek in the Village of Elm Grove and found to be both technically and economically feasible. Under this floodland management measure, up to 181 structures would be floodproofed and approximately 19 structures would be removed.

Source: SEWRPC.

Table 25

PRINCIPAL FEATURES AND COSTS AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE VILLAGE OF ELM GROVE

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
Number	Name	Description		Capital Cost: Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	
1	No Action	--	Yes	--	--	--	--	362.8	0	-362.8	0	No	--	--	No
2	Detention Storage	215 acre-feet detention reservoir on Dousman Ditch in the City of Brookfield	Yes	Reservoir and associated works	514.2[e]	32.6[e]	5.1[e]	37.7[e]	160.0	122.3	4.24	Yes	1. Potential to retain public open space along Dousman Ditch primary environmental corridor	1. Resolve only about one-half of the flood problem 2. May encourage new flood-prone development 3. Need for the Village of Elm Grove to coordinate design, construction, and financing with the City of Brookfield	No
3	Structure Floodproofing and Removal	a. Floodproof up to 156 residential and 24 commercial and other structures b. Remove up to 19 residential structures	Yes	Floodproofing Removal Subtotal	580.0 1,290.0 1,870.0	118.8	0.0	118.8	362.8	244.0	3.05	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	No
4	Major Channel Modification	a. 2.00 miles of major channelization b. Replace seven stream crossings	Yes	Channelization Bridges Subtotal	1,865.1 1,796.1 3,661.2	232.3	1.0	233.3	362.8	129.5	1.56	Yes	1. Opportunity to develop an urban-oriented parkway through the business-commercial area	1. Aesthetic impact in residential areas	No
5	Minor Channel Modification	1.92 miles of minor channel clean-out	No	--	--	--	--	--	--	--	--	--	--	--	No
6	Dikes and Floodwalls	a. 2.42 miles of dikes b. 1.60 miles of floodwall c. Replace 13 stream crossings d. Install six storm water pumping stations	Yes	Dikes Floodwalls Bridges Pumping stations Subtotal	692.0 1,574.5 2,123.6 390.0[f] 4,780.1	303.3	11.2	314.5	362.8	43.3	1.15	Yes	--	1. Aesthetic impact of visual barrier 2. Pumping station operation and maintenance are critical to effective functioning of the system	No
7	Bridge and Culvert Alteration or Replacement	Replace the four stream crossings causing the greatest backwater	No	--	--	--	--	--	--	--	--	--	--	--	No
8	Channelization-Storage Composite	a. 215 acre-feet detention reservoir b. 2.00 miles of major channelization c. Replace seven stream crossings	Yes	Reservoir Channelization Bridges Subtotal	514.2 1,688.6 1,553.7 3,756.5	238.2	6.1	244.3	362.8	118.5	1.49	Yes	1. Opportunity to use the channelization component for development of an urban oriented parkway through the business-commercial area	1. Aesthetic impact of channelization component in residential areas 2. Need for the Village of Elm Grove to coordinate design, construction, and financing of detention storage with the City of Brookfield 3. Upstream storage may encourage new flood-prone development	No
9	Storage-Major Channelization-Intermediate Channelization-Floodproofing Composite	a. 215 acre-feet detention reservoir b. 0.91 miles of major channelization c. 1.14 miles of inter-mediate channelization d. Replace seven stream crossings e. Floodproofing up to 105 residential structures	Yes	Reservoir Major channelization Intermediate channelization Bridges Floodproofing Subtotal	514.2 1,055.1 122.9 1,553.7 26.3 3,272.2	207.6	6.6	214.2	362.8	148.6	1.69	Yes	1. Potential to retain public open space along Dousman Ditch primary environmental corridor 2. Floodproofing component would provide immediate partial flood relief at discretion of property owners 3. With floodproofing component, some costs could be borne by beneficiaries 4. Opportunity to use the channelization component for development of an urban-oriented parkway through the business-commercial area	1. Storage component may encourage new flood-prone development 2. Complete, voluntary implementation of floodproofing unlikely and therefore left with a residual flood problem 3. Overland flooding and some attendant problems remain with floodproofing 4. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur 5. Although less than that of major channelization, the intermediate channelization component will have an aesthetic impact in residential areas 6. Erosion and attendant maintenance, aesthetic, and downstream sediment deposition are likely for the intermediate channelization component 7. Need for the Village of Elm Grove to coordinate design, construction, and financing of detention storage with the City of Brookfield	Yes

[a] Economic analyses are based on an annual interest rate of 6 percent and assume a 50 year amortization period and project life.

[b] A preliminary technical and economic assessment of temporary storage in mined chambers beneath the watershed indicated that while this would be technically feasible it would be an extremely uneconomic means of resolving flood problems in all or portions of the watershed.

[c] Economic analyses were not done for technically impractical alternatives.

[d] Presented only for technically and economically feasible alternatives.

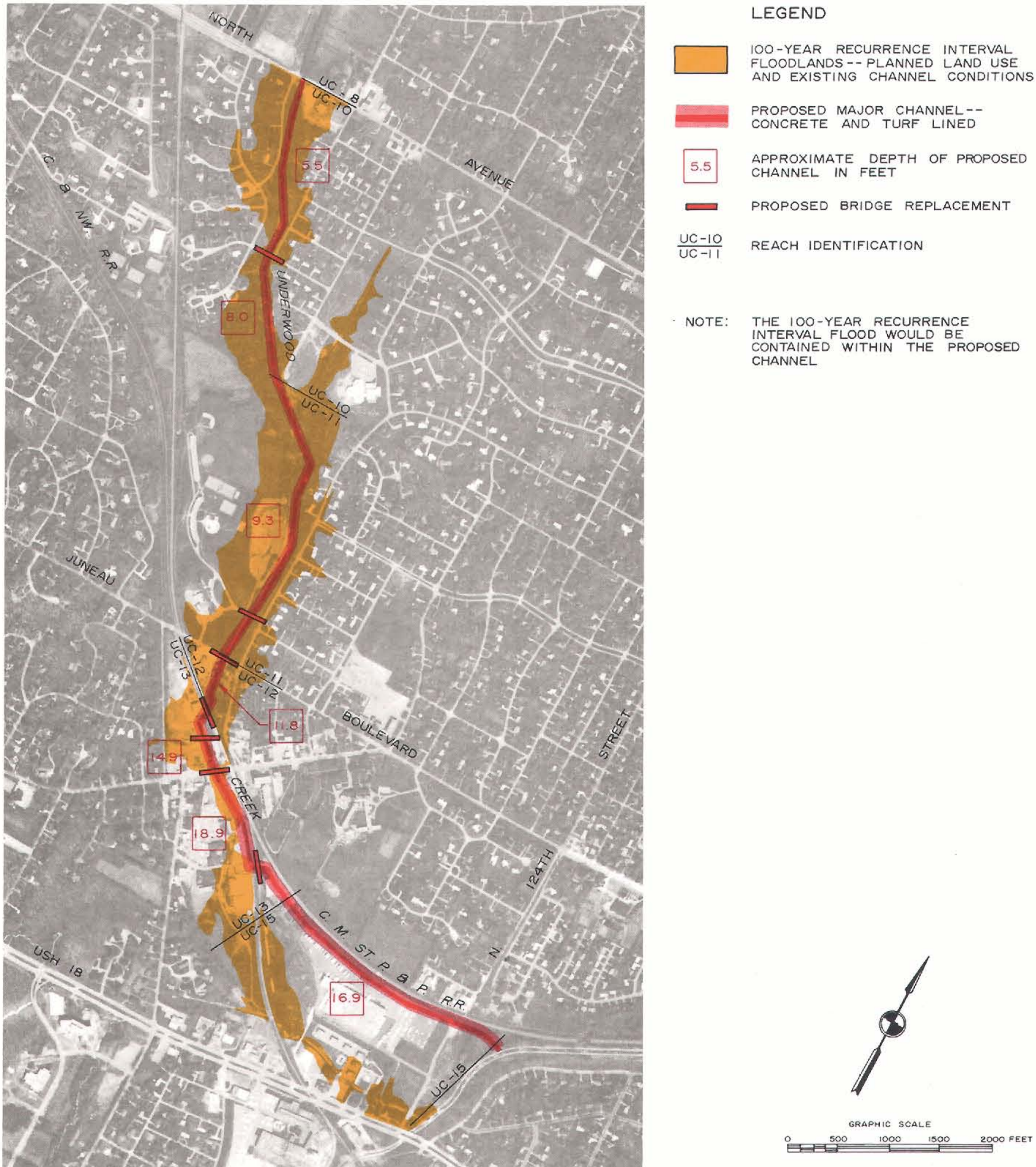
[e] Based on the assumption that the total average annual cost of $46,200 for the detention reservoir would be shared by the Village of Elm Grove and the City of Brookfield in proportion to the flood damage mitigation benefits derived by each community.

[f] Present worth cost based on a 25 year economic life.

Source: SEWRPC.

Map 22

MAJOR CHANNEL MODIFICATIONS ALONG UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE



The deepening, widening, and straightening along two miles of Underwood Creek, supplemented with the replacement of the seven stream crossings, was examined as a potential structural flood control measure and was found to be technically practicable and economically feasible. This measure would have a negative aesthetic impact on the primarily residential area north of Juneau Boulevard because the attractiveness of the existing natural channel and floodplain would be compromised by the cross-section enlargement required for the channelization project and by the placement of concrete invert and sidewalls. In contrast, channelization of the Underwood Creek reach downstream of Juneau Boulevard within the Village of Elm Grove would provide an opportunity to restore some of the aesthetic value of the riverine area in the business commercial area of the Village by development of an urban-oriented parkway.

Source: SEWRPC.

about 1.5 feet at the Waukesha-Milwaukee County line. The width of the invert or bottom of the concrete channel within the Village of Elm Grove would be 20 feet and side slopes would be one on three. The bottom, and the side slopes up to a 10-year flood stage, would be lined with concrete resulting in a total concrete width of from 35 to 44 feet.

The channelization would require the demolition and replacement of the existing bridges at the following seven crossings—listed in downstream order—of Underwood Creek in the Village of Elm Grove: Marcella Drive, the access road to the Village Hall, Juneau Boulevard, the Chicago, Milwaukee, St. Paul and Pacific Railroad, a private bridge, Watertown Plank Road, and, again, the Chicago, Milwaukee, St. Paul and Pacific Railroad. The cost of all of the above-bridge replacements was charged against the major channelization alternative. In addition, the 575-foot-long section of conduit that presently conveys Underwood Creek beneath the shopping center parking lot immediately south of Watertown Plank Road would be removed and replaced with a large open channel.

Assuming that the aforementioned major channelization project would be fully implemented and utilizing an interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at about $233,300 consisting of the following: amortization of the $1,865,100 capital cost of the channel modifications, amortization of the $1,796,100 capital cost of bridge demolition and reconstruction, and $1,000 in annual operation and maintenance costs. Assuming that major channelization would completely eliminate all direct and indirect flood damages along Underwood Creek in the Village of Elm Grove, the average annual flood abatement benefit is estimated at about $362,800, yielding a benefit-cost ratio of 1.56, and an annual excess of benefits over costs of about $129,500. Therefore, major channelization may be considered technically and economically feasible through the Village of Elm Grove.

The major channelization proposal would have a potentially negative aesthetic impact on that portion of Underwood Creek north of Juneau Boulevard and would, on the other hand, have a potentially positive aesthetic impact on that portion of Underwood Creek south of Juneau Boulevard, particularly the reach passing through the commercial area of the Village. In the primarily residential area north of Juneau Boulevard, the attractiveness of the existing natural channel and floodplain would be compromised by the cross-section enlargement required for the channelization project and by the placement of concrete invert and sidewalls. These changes would be apparent to residents of the adjacent areas and would constitute a negative aspect, particularly to those homeowners who value their residential location because of the naturalness of Underwood Creek and its natural floodplains.

As discussed in Chapter III of this volume, the area along Underwood Creek in the Village of Elm Grove between Juneau Boulevard on the north and the Village limits on the east represents a unique situation in the watershed in that it comprises a sizeable break or discontinuity in the primary environmental corridor system. This area could be restored to corridor use, however, by developing a continuous parkway from Juneau Boulevard downstream to the east limits of the Village. This parkway would, because of the surrounding intensive business and commercial land uses, necessarily have to have an urban characteristic and would offer only limited outdoor recreational opportunities such as pleasure walking while adding beauty and "green" open space to the urban area and providing for continuity in the primary environmental corridor. The proposed channelization through this portion of the Village could provide the major focus or framework within which such an urban oriented parkway could be developed. The channelized reach from Juneau Boulevard downstream to the east limits of the Village, or portions of that reach, could be developed as an urban parkway with grassy areas, pleasure walks, and attractive plantings of trees and shrubs.

Minor Channelization: An often suggested method for resolving flood problems—but one usually ineffective insofar as major flood events are concerned—is to undertake a program of minor and selective channel clearing, deepening, widening, and shaping. This approach is intended to remove "obstructions" to flow with little effort and expense, thereby making the channel system itself more efficient so that flood flows may be conveyed at lower stages.

A minor channel clearing, deepening, widening, and shaping alternative was developed for a reach of Underwood Creek in the Elm Grove-Brookfield area under the Menomonee River watershed study in order to demonstrate the limitations of this technique. Under this alternative, it was assumed that a 1.92 mile reach of Underwood Creek extending from Juneau Boulevard in the Village of Elm Grove upstream to Clearwater Road in the City of Brookfield would be cleared of obstructions, deepened by about one-half foot, have its bottom width increased by 10 percent on each side and shaped so as to increase the hydraulic efficiency. Hydraulic analyses of this alternative, as summarized in Table 26, indicate that the stages of the 5-, 50- and 100-year recurrence interval floods under year 2000 plan land use conditions could be expected to be lowered by only very small amounts as a result of the minor channel improvement; for example, for the 100-year flood flow condition, a maximum decrease of 0.2 feet could be expected immediately downstream of Marcella Avenue and of Clearwater Road. As a result, overland flooding and average annual monetary flood damages would not be significantly reduced.

Based on the inability of this channel clearing, deepening, widening, and shaping alternative to achieve significant flood stage and damage reductions, this alternative was deemed technically unsound for application in the Village of Elm Grove, the City of Brookfield, and in other flood-prone reaches of the watershed. Accordingly, this alternative was omitted from further consideration as a viable structural flood control alternative for the Menomonee River watershed.

Table 26

EFFECT OF MINOR CHANNEL MODIFICATIONS ON 5-, 50-, AND 100-YEAR RECURRENCE INTERVAL FLOOD STAGES ALONG UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE AND THE CITY OF BROOKFIELD

Civil Division	Location			5-Year Flood Flow Conditions[a]				50-Year Flood Flow Conditions[a]				100-Year Flood Flow Conditions[a]			
	River Mile Station	Structure Name or Other Location	Structure Number	Discharge (cfs)	Stage Without Minor Channelization (feet above msl)[b]	Stage With Minor Channelization (feet above msl)[b]	Stage Decrease (feet)	Discharge (cfs)	Stage Without Minor Channelization (feet above msl)[b]	Stage With Minor Channelization (feet above msl)[b]	Stage Decrease (feet)	Discharge (cfs)	Stage Without Minor Channelization (feet above msl)[b]	Stage With Minor Channelization (feet above msl)[b]	Stage Decrease (feet)
Village of Elm Grove	3.66			637	741.2	741.2	0.0	1,514	745.3	745.3	0.0	1,943	745.7	745.7	0.0
		Juneau Boulevard	1295												
	3.68			594	743.0	743.0	0.0	1,514	745.4	745.4	0.0	1,943	745.8	745.8	0.0
	3.75			594	743.0	743.0	0.0	1,514	745.4	745.4	0.0	1,943	745.8	745.8	0.0
		Village Hall Bridge	1300												
	3.77			594	743.7	743.5	0.2	1,514	745.5	745.5	0.0	1,943	745.9	745.9	0.0
	3.82			594	743.7	743.5	0.2	1,514	745.5	745.5	0.0	1,943	745.9	745.9	0.0
	3.90			594	743.7	743.5	0.2	1,514	745.5	745.5	0.0	1,943	746.0	745.9	0.1
	4.00			594	743.8	743.5	0.3	1,514	745.5	745.5	0.0	1,943	746.0	746.0	0.0
	4.12			594	743.9	743.7	0.2	1,514	745.6	745.6	0.0	1,943	746.1	746.1	0.0
	4.19			594	744.0	743.8	0.2	1,514	745.8	745.7	0.1	1,943	746.2	746.2	0.0
	4.26			594	744.5	744.2	0.3	1,514	746.1	745.9	0.2	1,943	746.6	746.4	0.2
	4.34			594	745.9	745.5	0.4	1,514	747.2	747.1	0.1	1,943	747.6	747.5	0.1
	4.40			594	746.2	745.9	0.3	1,514	747.5	747.4	0.1	1,943	748.0	747.8	0.2
	4.47			594	747.0	746.6	0.4	1,514	748.4	748.2	0.2	1,943	748.9	748.7	0.2
		Marcella Avenue	1305												
	4.49			594	748.2	747.9	0.3	1,514	749.0	749.2	(0.2)[c]	1943	749.4	749.6	(0.2)[c]
	4.57			594	748.7	748.4	0.3	1,514	750.7	750.6	0.1	1,943	751.4	751.4	0.0
	4.67			594	748.9	748.7	0.2	1,514	750.9	750.9	0.0	1,943	751.6	751.6	0.0
	4.74			594	749.0	748.7	0.3	1,514	750.9	750.9	0.0	1943	751.7	751.7	0.0
Village of Elm Grove	4.81			594	749.1	748.8	0.3	1,514	751.0	751.0	0.0	1,943	751.7	751.7	0.0
		North Avenue (CTH M)	1310												
City of Brookfield	4.83			594	751.2	751.0	0.2	1,514	752.1	752.1	0.0	1,943	752.3	752.3	0.0
	4.92			594	751.2	751.0	0.2	1,514	752.1	752.1	0.0	1,943	752.3	752.3	0.0
	5.02			594	751.2	751.0	0.2	1,514	752.1	752.1	0.0	1,943	752.4	752.4	0.0
	5.13			594	751.2	751.1	0.1	1,514	752.2	752.2	0.0	1,943	752.5	752.4	0.1
	5.23			594	751.4	751.3	0.1	1,514	752.6	752.5	0.1	1,943	752.9	752.9	0.0
	5.32			594	751.6	751.4	0.2	1,514	752.8	752.8	0.0	1,943	753.2	753.2	0.0
	5.41			594	752.1	752.1	0.0	1,514	753.2	753.1	0.1	1,943	753.6	753.5	0.1
	5.51			594	752.6	752.4	0.2	1,514	753.6	753.5	0.1	1,943	754.0	753.8	0.2
	5.58			594	754.3	753.5	0.8	1,514	756.3	756.3	0.0	1,943	756.5	756.7	(0.2)[c]
		Clearwater Road	1315												
	5.60			594	756.2	756.2	0.0	1,514	757.5	757.5	0.0	1,943	757.9	757.9	0.0
	5.66			594	757.0	757.0	0.0	1,514	758.6	758.6	0.0	1,943	758.9	758.9	0.0

[a] *Year 2000 land use plan conditions.*

[b] *Mean Sea Level.*

[c] *Stage increase.*

Source: SEWRPC.

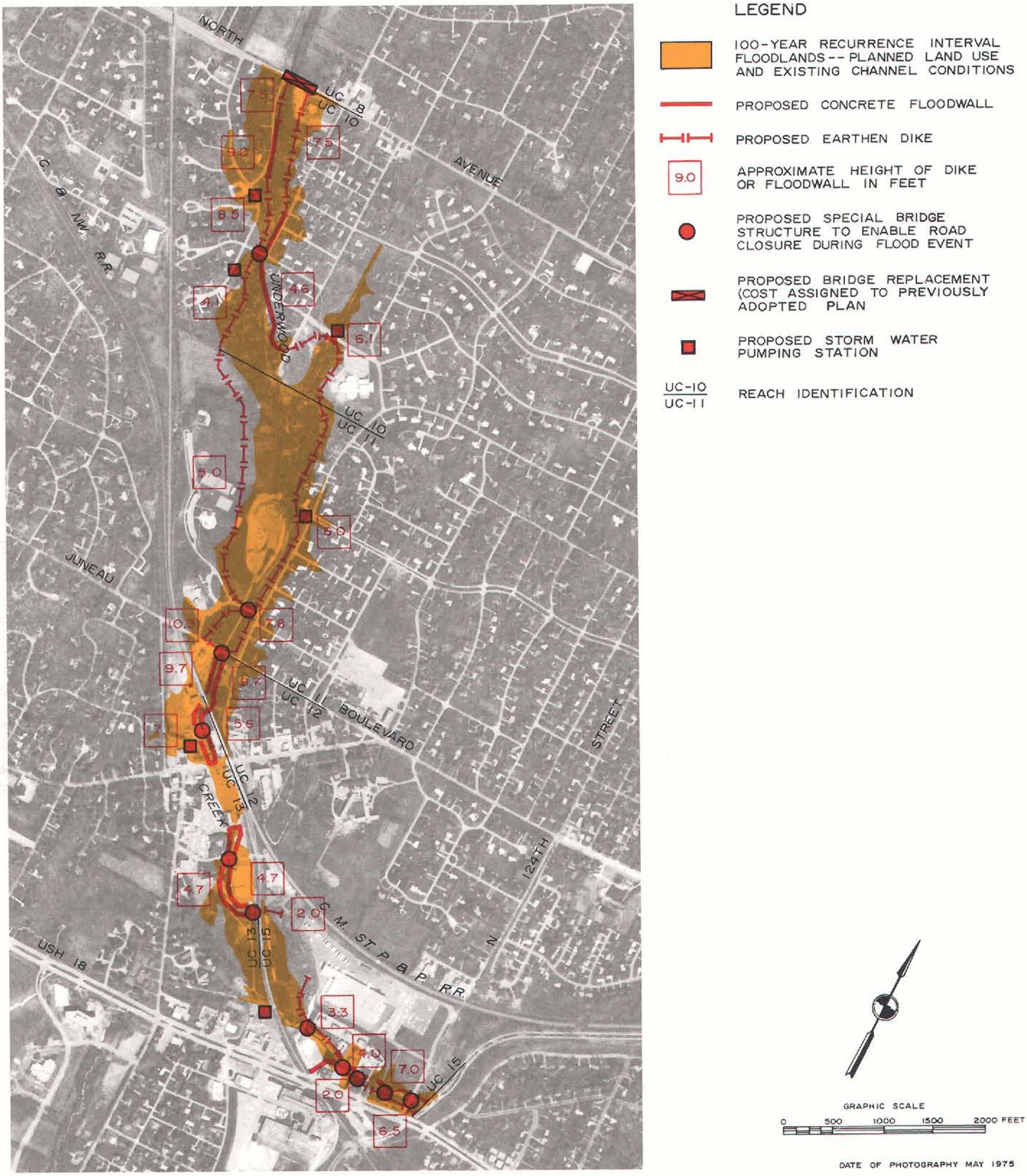
Dikes and Floodwalls: A dike and floodwall alternative was developed and analyzed for the lands subjected to flooding by Underwood Creek in the Village of Elm Grove in order to determine if such a structural measure would provide a technically sound, economically viable, and environmentally acceptable solution to the existing and probable future flood problems. The 100-year recurrence interval flood discharge under year 2000 land use plan conditions was used as the basis for a preliminary design of the dikes and floodwalls.

The dike and floodwall alternative for Underwood Creek in the Village of Elm Grove is shown on Map 23. A schedule of the physical characteristics of the dikes and floodwalls and the attendant costs and benefits is presented in Table 25. Under this alternative, a total of 4.02 miles of earthen dikes and concrete or sheet steel floodwalls similar to those shown on Figure 4 would be constructed along most of both sides of the 2.25-mile-long reach of Underwood Creek within the Village of Elm Grove. About 2.42 miles of earthen dike and about 1.60 miles of concrete or sheet steel floodwall would be required. Extensive use of the more costly concrete or sheet steel floodwalls rather than earthen dikes would be necessary in the downstream portion of the Village due to the limitations imposed by the very narrow band of unoccupied land located between the edge of Underwood Creek and the existing primarily commercial structures located along much of the flood-prone reach. In order to convey the design flood flow with a minimum free-board of two feet, the earthen dikes and concrete floodwalls would be extremely high in some locations with a maximum height above the existing ground level of 11.0 feet along that reach of Underwood Creek between Watertown Plank Road and the downstream Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge.

The dike and floodwall alternative would require the construction of new bridges at 13 crossings of the Underwood Creek in order to contain the floodwaters within the confines of the dikes and floodwalls. These new structures would be required at the following 13 crossings—listed in downstream order—of Underwood Creek in the Village: W. North Avenue, Marcella Drive, the access road to the Village Hall, Juneau Boulevard, the private crossing immediately north of Watertown Plank Road, a private crossing south of the parking lot located south of Water-

Map 23

DIKE-FLOODWALL SYSTEM ALONG UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE



A combination of earthen dikes, concrete floodwalls, and storm water pumping facilities intended to contain flood flows and prevent inundation of riverine area structures was examined as a possible measure to resolve existing and forecast flood problems along Underwood Creek in the Village of Elm Grove. While this measure was shown to be technically practicable and economically feasible, the dikes and floodwalls, which would have a height above existing ground grade of as much as 10 feet, would entail an unacceptably high aesthetic "cost" particularly in the northern, primarily residential, portion of the village.

Source: SEWRPC.

town Plank Road, another private crossing located immediately west of the Milwaukee Road railroad embankment, and six additional private crossings located along that portion of Underwood Creek that lies near to and parallels Bluemound Road.

In addition, the dike-floodwall alternative would have to include provision for the construction of a minimum of six major storm water lift or pumping stations and backwater gates near the end of storm sewer outfalls that are tributary to Underwood Creek. These facilities would be required to prevent the movement of floodwaters from the river into the surrounding urban area via these storm sewers and drainage channels and to prevent the accumulation of lateral runoff behind the dikes and floodwall creating local drainage problems.

Assuming that the dike and floodwall project would be fully implemented and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at $314,500, consisting of the following: amortization of the $2,266,500 capital cost of the dikes and floodwalls and the land necessary to construct them, amortization of the $2,123,600 capital cost of new river crossings, amortization of the $390,000 capital cost of backwater control and pumping facilities, and $11,200 in annual operation and maintenance costs of the dikes, floodwalls, and pumping facilities. Assuming that the dike-floodwall system would completely eliminate all direct and indirect flood damages along Underwood Creek in the Village of Elm Grove, the average annual flood abatement benefit is estimated at about $362,800, yielding a benefit-cost ratio of 1.15 and an annual excess of benefits over costs of about $43,300. Therefore, the Village of Elm Grove dike and floodwall plan element, as described herein, may be considered both technically sound and economically feasible.

As opposed to the favorable economic features of the dike-floodwall alternative, the great height of the dikes and floodwalls would make the structures extremely unsightly. This height would be necessitated by high flood stages relative to existing riverine area topography and by engineering criteria that require a freeboard of at least two feet above that stage. The residents protected by the dikes and floodwalls, particularly those property owners living nearest the river, would generally have their view of Underwood Creek blocked by the structures and would encounter difficulty in gaining access to the stream because most of the dikes and floodwalls would have crests at a height of 5.0 feet or more above the existing elevation of the river edge. The dike and floodwall alternative, particularly in the northern portion in the Village, would seriously detract from the aesthetic pleasure derived from driving along riverine areas as well as from living adjacent to these areas. The structures in this area, which would lie adjacent to and on the river side of any local streets which parallel Underwood Creek, would range in height from 4.0 to 10.0 feet and thus constitute a visual barrier to pleasure drivers as well as to people residing in the area.

A high aesthetic cost would also be incurred by the commercial area of the Village inasmuch as the massive concrete or sheet steel walls required in that area would detract from the overall appearance of this shopping center. While the costs associated with such aesthetically undesirable characteristics are elusive and difficult to assign a monetary value to, they are, nevertheless real. These high aesthetic "costs" may be expected to be a major factor in developing local opposition to any dike and floodwall alternative.

Bridge and Culvert Alteration or Replacement For Flood Control Purposes: The removal and possible replacement of selected bridges or culverts on Underwood Creek within the Village of Elm Grove was examined as a potential means of significantly reducing flood problems in the reaches immediately upstream of these crossings. Bridges and culverts producing backwater in excess of 1.0 feet in flood-prone reaches were selected for inclusion in the technical examination of this alternative. The four bridges or culverts that were identified consist of a private bridge at River Mile 2.83, the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 3.10, a private bridge at River Mile 3.12, and the Marcella Avenue bridge at River Mile 4.48.

Hydraulic analyses based upon the 100-year recurrence interval flood discharge corresponding to year 2000 plan conditions and the assumption that the above-listed four bridges were either removed entirely or were replaced by structures having essentially no backwater effect, indicate that removal or replacement of the bridges could be expected to reduce the 100-year recurrence interval flood stage through the Village of Elm Grove by a maximum of only 1.0 foot, this maximum decrease occurring at the private bridge located at River Mile 2.83.

Based on the above hydraulic analyses, it was concluded that the removal or replacement of selected bridges and culverts within the Village of Elm Grove did not constitute a technically feasible means of significantly reducing the magnitude of the flood problem that prevailed within the community and, therefore, further technical and economic analyses of this floodland management alternative were not warranted.

Concluding Statement: Five distinctly different structural floodland management alternatives—storage in a detention reservoir, major channel modifications, minor channel modifications, dikes and floodwalls, bridge and culvert alterations or replacement—and one nonstructural measure—a combination of structure floodproofing and structure removal—were examined as possible solutions to the serious flood problem that exists along Underwood Creek in the Village of Elm Grove. In addition, a seventh alternative, that of taking no action, is available to the public agencies concerned, and the flood damages attendant to this alternative provide an important basis for the analyses of the potential benefits associated with each of the other alternatives.

The principal features of, and the costs and benefits associated with, each of the floodland management alternatives are summarized in Table 25 together with the major favorable and unfavorable nontechnical and noneconomic considerations likely to influence selection of the most desirable solution. In addition to the alternatives identified in the table, the diversion of floodwaters to Lake Michigan and the temporary storage of floodwaters in mined storage chambers beneath the watershed were subjected to a preliminary assessment and, although these two alternatives were determined to be technically feasible, both were shown to be economically unsound by a wide margin.

Excluding the "no action" approach, all of the above structural and nonstructural alternatives were found to be technically feasible with the exception of minor channel modification and bridge and culvert alteration or replacement. The remaining four measures were found to be economic, thus providing four separate technically and economically feasible solutions to the flood problems along Underwood Creek in the Village of Elm Grove.

Even though structure floodproofing and removal constitutes a technically and economically feasible floodland management alternative for the Village of Elm Grove, this alternative was eliminated from further consideration for four important reasons: First, complete implementation of a voluntary structure floodproofing and removal program is unlikely and with partial implementation, the Village of Elm Grove would be left with a significant residual problem whenever a major flood event occurs. Assuming that numerous individual property owners incur the necessary cost to implement floodproofing and further assuming that the floodproofing devices are adequately maintained, community officials may still be faced with the problem of reducing the flood threat to those structures that have not been voluntarily floodproofed. Second, other viable alternatives are available, each of which could be applied with a significantly higher likelihood of success in eliminating most of the Underwood Creek flood problems. Third, even if a voluntary structure floodproofing program were completely carried out, the Village of Elm Grove would still be subjected to extensive overland flooding that would hamper routine access to and from some riverine area structures, would continue to periodically close local streets to automobile traffic, and would interfere with the rapid movement of emergency vehicles. Furthermore, yard and street damages and cleanup costs would remain with the structure floodproofing and removal alternative, and sanitary and storm sewers would continue to experience surcharging. Fourth, some floodproofing is very likely to be applied without adequate professional advice, and, as a result, structure damage is likely to occur and once again Village officials are likely to be asked to assist in the resolution of the problem.

Dikes and floodwalls also were eliminated from further consideration partly because of the undesirable aesthetic impact of these structures in both residential and commercial areas of the Village, particularly when other equally effective and aesthetically more acceptable alternatives are available. Another factor contributing to the elimination of the dike and floodwall alternative is its dependence on the quick response and reliability of storm water pumping stations. This is a significant contrast with the other remaining available structural alternatives—channelization and detention storage—which operate on a gravity flow basis and are not, therefore, so heavily dependent upon maintenance practices, on the reliability of automatic controls, and on uninterrupted power supply.

Although detention storage would abate only about 45 percent of the flood problem in the Village of Elm Grove as measured by reduction in average annual flood damages, this measure does exhibit very favorable benefit-cost features. Therefore, another alternative was developed consisting of a combination of major channel modification and detention storage since such a combination would permit a reduction in the channel cross-section and, therefore, effect a cost saving in the channelization component that might offset the additional cost associated with detention storage. The major channelization component of this channelization-storage alternative was sized to convey the 100-year flood discharge that would exist under year 2000 plan conditions with the detention reservoir. The channel would be similar to that described above except that it would not be so deep. Proceeding in a downstream direction, channelization would lower the existing Underwood Creek channel grade by about 2.0 feet at Marcella Drive, about 4.0 feet at Juneau Boulevard, about 3.0 feet at Watertown Plank Road, and about 1.0 feet at the Waukesha-Milwaukee County line. These grade lowerings are 0.5, 2.5, 5.0, and 0.5 feet, respectively, less than what would be required if only channelization were used to provide flood protection.

The annual cost of the channelization component of the channelization-storage alternative is estimated at about $206,600, including amortization of the $1,688,600 capital cost of the channel modification, amortization of the $1,553,700 capital cost of the attendant bridge demolition and reconstruction, and $1,000 in annual operation and maintenance costs. The estimated cost is $26,700 less than the alternative employing only channelization. The annual cost of the storage component of the channelization-storage alternative that would be assigned to the Village of Elm Grove is estimated at $37,700 including: amortization of $514,200 of the total $630,100 capital cost of the land and structures and other facilities and responsibility for $5,100 of the total $6,200 annual operation and maintenance costs. The costs of the reservoir were assigned on the assumption that costs would be shared by the Village of Elm Grove and the City of Brookfield in proportion to the flood damage mitigation benefits derived in each community which would total $36,000 per year in Brookfield and $160,000 per year in Elm Grove. Therefore, the total average annual cost of the channelization-storage alternative, as shown in Table 25, is estimated at about $244,300, which is $11,000, or 5 percent more than the $233,300 annual cost of the major channel modification alternative. The 5 percent difference in estimated costs for the channelization alternative and the composite channelization-storage alternative is within the likely error of the cost estimates and, therefore, it may be concluded that there is no significant cost difference between these two alternatives. Assuming that the channelization-storage alternative would completely eliminate all direct and indirect flood damages along Underwood Creek in the Village of Elm Grove, the average annual flood abatement benefit is estimated at about $362,800, yielding a benefit-cost ratio of 1.49 and an annual excess of benefits over costs of about $118,500. Therefore, the channelization-storage alternative may be considered a technically and economically feasible solution to the existing and forecast Underwood Creek flood problems in the Village of Elm Grove.

As was the case with the channelization alternative, the channelization-storage alternative would have a potentially negative aesthetic impact on that portion of Underwood Creek north of Juneau Boulevard and would, on the other hand, have a potentially positive aesthetic impact on that portion of Underwood Creek south of Juneau Bouldvard, particularly the reach passing through the commercial area of the Village. As discussed in Chapter III of this volume, the latter riverine area could be redeveloped as a continuous parkway from Juneau Boulevard downstream to the east limits of the Village. The channelization component of the channelization-storage alternative could provide the major focus, or framework, within which such an urban-oriented parkway could be developed. The channelized reach could be developed as an urban parkway with grassy areas, pleasure walks, and attractive plantings of trees and shrubs. Another potentially troublesome feature of the channelization-storage alternative is the need to coordinate the design, construction, and financing of the storage reservoir component with the City of Brookfield since the reservoir site is in Brookfield.

After due consideration of the various technical and economic features and other aspects of the channelization alternative and the channelization-storage alternative, it was recommended by the Commission staff that channelization be employed to resolve existing and forecast flood problems along Underwood Creek in the Village of Elm Grove. In the event that the City of Brookfield elected to develop a detention reservoir upstream of the Village of Elm Grove on Dousman Ditch, then the size of the channel cross-section through Elm Grove could be reduced accordingly.

Action of the Menomonee River Watershed Committee: After careful consideration of the five technically and economically feasible floodland management alternatives developed by the Commission staff for Underwood Creek in the Village of Elm Grove and of the Commission staff recommendation that channelization or channelization in combination with upstream storage be employed to resolve existing and forecast flood problems in that reach, the Menomonee River Watershed Committee requested that the staff develop an additional alternative. This alternative consists of four parts: a detention storage reservoir located upstream of the Village on Dousman Ditch in the City of Brookfield; major channelization and necessary hydraulic structure replacement along Underwood Creek in the Village of Elm Grove with the major channelization terminating in the form of a drop structure immediately upstream of the Juneau Boulevard bridge; modest, herein termed intermediate channel improvements—defined as development of a turf channel sized so as to convey the 10-year recurrence interval flood discharge under year 2000 plan conditions—and necessary hydraulic structure alteration along the Underwood Creek reach between Juneau Boulevard and W. North Avenue; and floodproofing of those structures along the Juneau Boulevard-W. North Avenue reach of Underwood Creek that are not adequately protected by channelization. The primary purpose of developing this storage-major channelization-intermediate channelization-structure floodproofing alternative was to reduce the aesthetic impact of the recommended major channelization alternative or the composite major channelization-storage alternative by reducing the depth, width, and cross-sectional area of the channelized section between Juneau Boulevard and W. North Avenue and by eliminating the use of a concrete invert and partial concrete sidewalls in this reach.

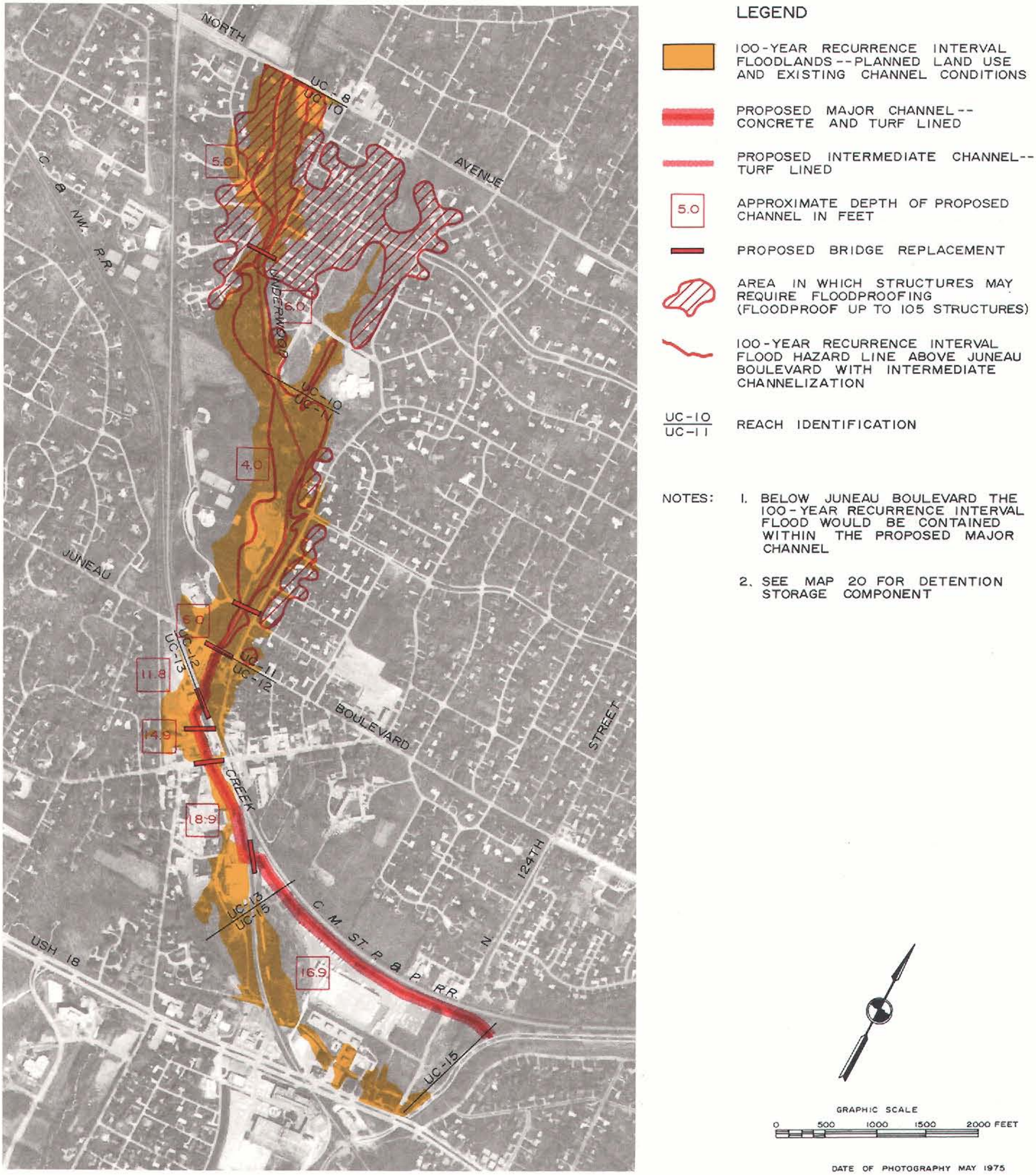
The storage-major channelization-intermediate channelization-structure floodproofing alternative is shown on Map 24 and the salient physical characteristics and the attendant costs and benefits are set forth in Table 25. The storage component of this alternative would consist of a 215 acre-foot detention reservoir located upstream on Dousman Ditch in the City of Brookfield and would be identical to the reservoir incorporated in the above storage and channelization-storage alternatives.

The 0.91-mile-long major channelization component of this composite alternative would be located along or near the alignment of Underwood Creek and would extend in an upstream direction from the Village of Elm Grove-City of Wauwatosa line at River Mile 2.53 and terminate at Juneau Boulevard in Elm Grove at River Mile 3.67. An approximate two-foot drop in the channel bottom would be provided immediately upstream of the Juneau Boulevard bridge and the alignment, grade, and cross-section of the channel downstream of that location would be identical to that of the channelization-storage alternative described above. The major channelization component of this alternative would require demolition and replacement of the existing bridges at the following five crossings—listed in downstream order—of Underwood Creek in the Village: Juneau Boulevard; the Chicago, Milwaukee, St. Paul, and Pacific Railroad; a private bridge; Watertown Plank Road; and another Chicago, Milwaukee, St. Paul, and Pacific Railroad crossing. In addition, the 575-foot-long section of conduit that presently conveys Underwood Creek beneath the shopping center parking lot immediately south of Watertown Plank Road would be removed and replaced with a large open channel.

The intermediate channelization component of this composite alternative would consist of a turf-lined channel sized to convey the 10-year recurrence interval flood flow of Underwood Creek under year 2000 plan conditions with the upstream reservoir in place. The intermediate channelization component of this alternative also would require replacement of the Marcella Street bridge and the Village Hall bridge. The term "intermediate channelization" is used herein to distinguish it from the minor channelization alternative described above. Minor channelization was defined as consisting of removing obstructions from the stream channel, deepening the stream channel by about one-half foot, increasing the bottom width of the channel by 10 percent on each side, and shaping the

Map 24

DETENTION STORAGE, MAJOR AND INTERMEDIATE CHANNELIZATION, AND STRUCTURE FLOODPROOFING ALONG UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE



At the request of the Menomonee River Watershed Committee, the Commission staff developed a floodland management alternative for the Village of Elm Grove consisting of a combination of upstream detention storage, major and intermediate channelization, and supplemental structure floodproofing. After reviewing the technical, economic, and environmental features of this and other alternatives, the Menomonee River Watershed Committee recommended that the storage-major channelization-intermediate channelization-floodproofing alternative be used to resolve existing and forecast flood problems along Underwood Creek in the Village of Elm Grove.

Source: SEWRPC.

channels to increase the hydraulic efficiency. A hydraulic analysis of the 1.92 mile Underwood Creek reach extending from Juneau Boulevard in the Village of Elm Grove upstream to Clearwater Road in the City of Brookfield indicated that under year 2000 plan conditions, minor channelization would reduce the 5-year recurrence interval flood stage by a maximum of 0.8 feet and the 50-year and 100-year recurrence interval flood stages by a maximum of only 0.2 feet. Intermediate channelization refers to the use of a completely turf-lined channel larger in cross-section than minor channelization so as to achieve greater flood stage reduction but having a smaller cross-section than that used in the channelization and channelization-storage alternatives.

Three factors were considered in selecting the 10-year recurrence interval flood discharge under conditions of the year 2000 plan and upstream detention reservoir as the basis for design of a turf-lined channel. First, it has been demonstrated that natural channels tend to be overtopped by floodwaters once on the average of about every two years; that is, natural channels contain flood flows up to approximately the two-year recurrence interval discharge. Therefore, the design discharge should be significantly higher than that of a two-year recurrence interval flow if the frequency of channel overtopping is to be significantly reduced. Secondly, since the analysis of minor channelization described above clearly indicated that a small alteration in the shape of the existing channel had no significant impact on 50- through 100-year recurrence interval flood stages, the cross-section selected for the intermediate channelization would have to be substantially larger than that selected for minor channelization in order to achieve a meaningful reduction in flood damages. Thirdly, inasmuch as the underlying reason for examining an alternative with intermediate channelization is to significantly reduce the aesthetic impact of the channel work in the affected reach, it is imperative that the intermediate channelization be sized so as to cause less alteration to the natural topography than would be caused by major channelization.

An examination of the size of turf channel required to convey 5- through 100-year recurrence interval flood flows through the Underwood Creek reach bounded by Juneau Boulevard and W. North Avenue under year 2000 plan conditions with the upstream detention reservoir in place revealed that a turf channel sized to carry flows in the 25- to 50-year recurrence interval range would have a cross-section quite similar to that of the concrete and turf channel envisioned in the major channelization-storage alternative. Thus, in order to minimize the aesthetic impact of the intermediate channel, it was necessary to select a design flow less than the 25-year recurrence interval discharge and, as discussed above, in order to achieve some reduction in flood stages it was necessary to select a design discharge more severe than the two-year recurrence interval flow. Therefore, the 10-year peak flood discharge of 520 cfs under year 2000 plan conditions with the upstream detention storage in place was selected for design of the channel.

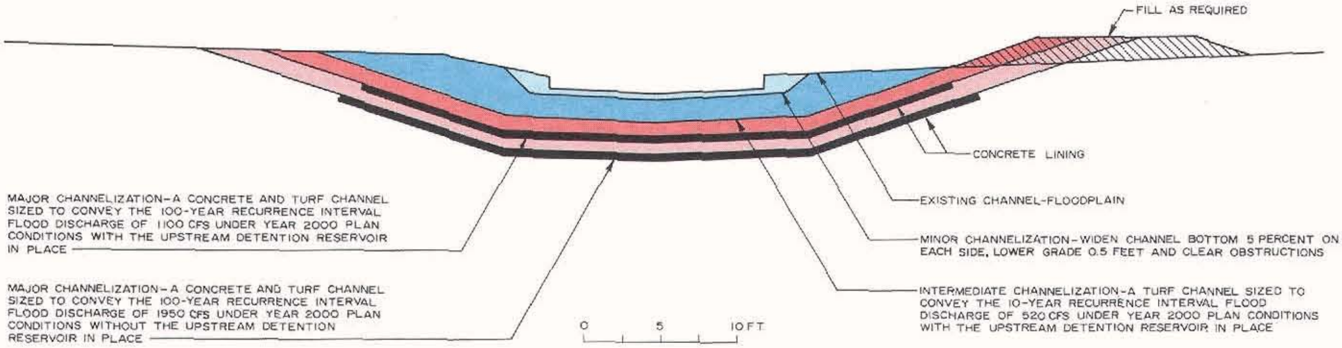
Figure 15 shows the relationships between the various cross-sections at River Mile 4.12 on Underwood Creek in the vicinity of Tonawanda School. These cross-sections are typical of those that would exist throughout the Juneau Boulevard-W. North Avenue reach. More specifically, Figure 15 compares channel floodplain cross-sections corresponding to existing topographic conditions, minor channelization, intermediate channelization, and major channelization with and without the upstream reservoir. The intermediate channelization would lower the existing channel grade at River Mile 4.12 approximately 3.5 feet or about two feet less than the channel would have to be lowered for major channelization with the upstream reservoir, and about five feet less than the channel would have to be lowered for major channelization without the upstream reservoir. Furthermore, the total width of the altered cross-section under conditions of intermediate channelization would be approximately 47 feet, or 87 percent of the total 54 foot width of the cross-section for major channelization with the upstream reservoir in place and 76 percent of the 62 foot width of the cross-section for major channelization assuming that the upstream detention reservoir is not in place. Assuming the upstream reservoir to be in place, the cross-sectional shape of the turf channel sized to carry a 10-year recurrence interval flood discharge approaches the cross-sectional shape of a concrete and turf channel designed to carry a 100-year recurrence interval discharge because the turf bottom and side walls in the former offer more resistance to flow than the combination of the concrete and turf in the latter. The Manning roughness coefficient, which is the quantitative measure of resistance to flow in an open channel, is about 0.035 for a turf channel and only about 0.017 for a concrete channel, indicating that the flow resistance of turf is approximately twice that of concrete.

A series of backwater computations was conducted to obtain the flood stage profiles that would exist upstream of Juneau Boulevard within the Village of Elm Grove with the intermediate channel in that reach and with major channelization downstream of Juneau Boulevard. These profiles were calculated so as to permit a comparison with those that would exist with major channelization throughout the entire length of Underwood Creek within the Village and with natural channel-floodplain conditions.

Assuming year 2000 conditions and existence of the upstream detention reservoir, major channelization would reduce the 100-year flood stage profile at River Mile 4.10—approximately midway between Juneau Boulevard and Marcella Street—by about four feet relative to existing channel-floodplain conditions, whereas intermediate channelization would reduce the 100-year recurrence interval flood stage profile by about 2.5 feet. At this same location, major channelization would reduce the 10-year recurrence interval flood stage profile by about 2.5 feet relative to existing channel-floodplain conditions, whereas intermediate channelization would reduce the 10-year flood stage profile by about 2.0 feet. In general, this backwater analysis indicates that intermediate channelization, a turf channel sized to carry the 10-year recurrence interval flood discharge, when applied to the Underwood Creek

Figure 15

CROSS-SECTIONS CORRESPONDING TO EXISTING TOPOGRAPHIC CONDITIONS, MINOR CHANNELIZATION, INTERMEDIATE CHANNELIZATION, AND MAJOR CHANNELIZATION AT RIVER MILE 4.12 ON UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE



Source: SEWRPC.

reach between Juneau Boulevard and W. North Avenue in combination with major channelization downstream of Juneau Boulevard, could be expected to produce 100-year flood stage profiles approximately 2.0 to 4.5 feet below those corresponding to existing conditions whereas major channelization could be expected to reduce 100-year flood stage profiles by 3.5 to 6.5 feet from existing conditions.

The floodproofing component of this alternative would require the floodproofing of up to 105 residential structures located along Underwood Creek in the reach bounded by Juneau Boulevard and W. North Avenue. This is about two-thirds of the number of structures that may require floodproofing or removal in this reach under the floodproofing-removal alternative examined above. Floodproofing would be required in this area to supplement the intermediate channelization inasmuch as that channelization would not lower flood stages throughout this reach beneath the basement floors of all structures.

The average annual cost of the composite detention storage-major channelization-intermediate channelization-structure floodproofing alternative, calculated using an annual interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $214,200 consisting of: $154,100 for amortization of the $2,421,900 capital costs of the major channel modifications and associated bridge replacement; $20,700 for amortization of the $309,800 capital costs of the intermediate channelization and associated bridge replacement; $1,700 for amortization of the $26,300 capital costs of the structure floodproofing; $1,500 for annual operation and maintenance costs attendant to the major and minor channelization; and $37,700 for the Village of Elm Grove share of the annualized cost—amortization of $514,200 in capital costs and $5,100 of operation and maintenance costs—of the upstream detention reservoir. Assuming that the combination of detention storage, major channelization, intermediate channelization, and structure floodproofing would be implemented so as to completely eliminate direct and indirect damages along Underwood Creek in the Village of Elm Grove, the average annual flood abatement benefit is estimated at about $362,800, yielding a benefit cost ratio of 1.69 and an annual excess of benefits over cost of $148,600. Therefore, the composite detention storage-major channelization-intermediate channelization-structure floodproofing alternative is both a technically practicable and economically feasible solution to the existing and forecast flood problem that exists along Underwood Creek in the Village of Elm Grove. The benefit-cost features of this alternative are very similar to the major channelization and channelization-storage alternatives recommended by the Commission staff in that all three alternatives yield the same benefit—$362,800 per year—while the annualized cost of the major channelization, major channelization-storage, and storage-major channelization-minor channelization-floodproofing alternatives are close, respectively $233,300, $244,300, and $214,200.

As shown on Table 25, this composite alternative would exhibit the various positive and negative features of the several alternatives used to synthesize it. Positive noneconomic and nontechnical characteristics of this detention storage major channelization-intermediate channelization-structure floodproofing alternative include: the potential to retain public open space along a portion of the Dousman Ditch primary environmental corridor, provision of immediate partial flood relief to some riverine property owners through application of floodproofing, assignment of flood protection cost directly to beneficiaries via the floodproofing portion of the alternative, and the opportunity to use the channelization component of the alternative for development of an urban-oriented parkway through the business-commercial area of the Village of Elm Grove.

Negative features of the composite alternative include: the possibility that upstream storage may impart a false sense of security in downstream areas and thereby encourage new flood-prone development; the likelihood that complete voluntary implementation of the floodproofing component will not be achieved, therefore leaving a residual flood problem; the problems associated with overland flooding which will remain in the areas provided with floodproofing; the strong possibility that some floodproofing will be applied without adequate professional advice, resulting in structure damage and danger to occupants; and, although less severe than a major channelization, the aesthetic impact of the intermediate channelization component in the residential areas.

Another negative feature of the detention storage-major channelization-minor channelization-floodproofing alternative is the likelihood of erosion problems in the turf-lined channel section between Juneau Boulevard and W. North Avenue. Backwater computations indicate that 2- through 100-year recurrence interval flood flows under year 2000 plan conditions and with the upstream reservoir in place would produce average velocities in the turf channel ranging from about four to six feet per second. Even if turf channels are well maintained, velocities in excess of about five feet per second may be expected to cause erosion problems. Therefore, it is apparent that the 1.14-mile-long reach of turf-lined channel would occasionally suffer erosion damage that would require repair and restoration by the Village of Elm Grove. In addition, the erosion would detract from the appearance of the channel and would result in the deposition of sediment and other eroded material downstream along Underwood Creek in the Village of Elm Grove and the City of Wauwatosa.

After reviewing the technical and economic and the nontechnical and noneconomic features of the six economically feasible alternatives, the Menomonee River Watershed Committee recommended that the storage-major channelization-intermediate channelization-floodproofing alternative be used to resolve existing and forecast flood problems along Underwood Creek in the Village of Elm Grove.

The Village of Elm Grove has installed a movable gate at the downstream end of the 575-foot-long conduit that conveys Underwood Creek beneath the shopping center parking lot south of Watertown Plank Road. The gate, when closed, provides a temporary, approximately 300,000 gallon reservoir maintained for fire-fighting purposes in the business-commercial area of the Village. Assuming implementation of recommended major channelization through this reach, a similar volume of water could be maintained for fire-fighting purposes by installing a movable gate to a height of approximately 2.5 feet above the channel grade at a location about 0.25 miles downstream of the Watertown Plank Road.

The City of Brookfield

The Flood Problem: As shown on Map 15, the City of Brookfield contains two flood-prone reaches of the Menomonee River system, one located along a 1.86-mile-long portion of Underwood Creek and one located along a 1.26-mile-long portion of Butler Ditch. Average annual monetary flood risks for these two reaches attributable to both primary and secondary flooding under existing conditions are estimated at about $59,200, while the average annual monetary flood risks under year 2000 land use and floodland development conditions are estimated at about $75,800, a 28 percent increase over existing conditions. It should be emphasized that the increase in average annual monetary damages under year 2000 plan conditions is attributed solely to anticipated changes in upstream land use development in the Underwood Creek and Butler Ditch subwatersheds inasmuch as the analysis presumes that no new flood-prone structures will be constructed in the City of Brookfield. As discussed earlier in this chapter, complete development of the floodland and nonfloodland portions of the watershed that are tributary to Underwood Creek and Butler Ditch in the City of Brookfield could be expected to result in an approximately two-fold increase in average annual monetary risks and, if additional flood-prone development were permitted within the flood-prone reaches, even higher monetary risks would be incurred. As a result of direct and indirect flood damages associated with Underwood Creek flooding, the City may be expected to incur about $337,000 in flood damages during the 100-year recurrence interval flood under existing conditions, whereas damages resulting from the 100-year recurrence interval flood under year 2000 plan conditions could be expected to approximate $387,000.

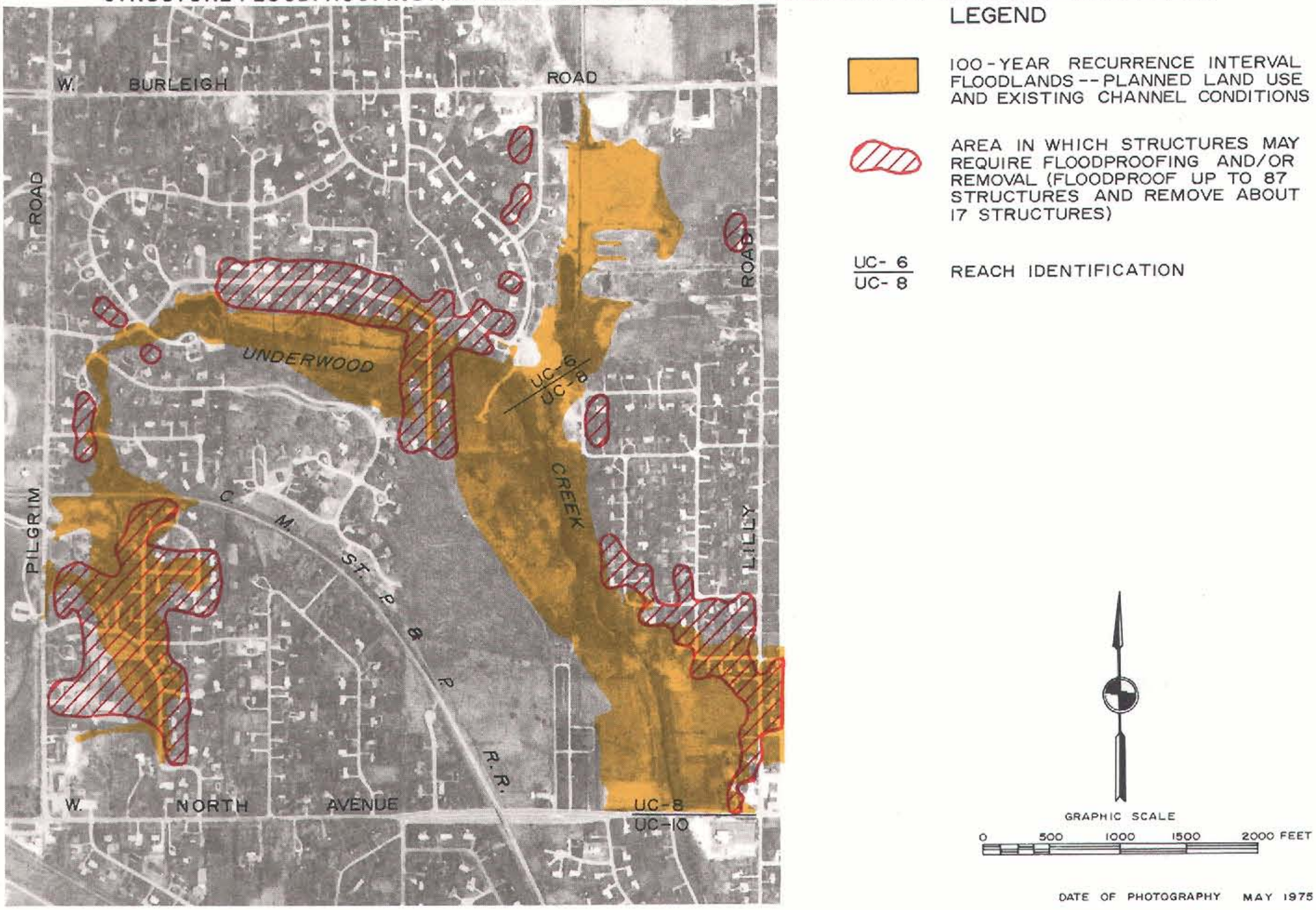
A flood problem also exists in the City of Brookfield along the South Branch of Underwood Creek in the vicinity of W. Bluemound Road (USH 18). Flood damages were not calculated, and alternative floodland management measures were not examined for this reach of Underwood Creek inasmuch as the associated flood hazard area contains only a few structures, and the problem that exists will be abated by replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge. This bridge, which obstructs the flow in the South Branch of Underwood Creek, was being altered in early 1976 as the watershed planning program was being completed. Alternative floodland management measures were developed separately for the flood-prone reaches along Underwood Creek and Butler Ditch. This approach was used because these reaches are contained within separate subwatersheds, each of which is tributary to the Menomonee River.

Floodproofing and Removal of Structures: A floodproofing and removal alternative was developed and analyzed to determine if such a structure-by-structure approach would constitute a technically, economically, and environmentally acceptable solution to the flood problem in the City. The design criteria and overall approach used in this analysis were identical to those applied in the Village of Elm Grove.

For the Underwood Creek flood-prone area, and as shown on Map 25, the analyses indicated that there were about 17 structures that would have to be removed from the 100-year recurrence interval floodlands under this alternative, and a total of about 87 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damages to private residences would be virtually eliminated by the floodproofing and removal. Table 27 sets forth a schedule of the approximate number of structures to be floodproofed and also summarizes the estimated costs and benefits. The equivalent average annual cost of the structure floodproofing measures calculated using an annual interest

Map 25

STRUCTURE FLOODPROOFING AND REMOVAL ALONG UNDERWOOD CREEK IN THE CITY OF BROOKFIELD



A combination of structure floodproofing and removal was examined as an alternative means for resolving existing and probable future flood problems in the residential areas lying along Underwood Creek in the City of Brookfield. This measure was determined to be technically practicable and economically feasible. Positive noneconomic and nontechnical considerations include immediate partial flood relief at the discretion of property owners and the fact that most of the cost would be borne by beneficiaries. On the negative side, it is unlikely that floodproofing and removal would be completely and effectively carried out on a voluntary basis. Furthermore, overland flooding and some of the attendant problems would remain.

Source: SEWRPC.

rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $65,700, consisting entirely of the amortization of the $1,036,300 capital cost—$57,600 for floodproofing and $978,700 for removal. The average annual flood abatement benefit is estimated at about $73,500, yielding a benefit-cost ratio of 1.12 and an excess of annual benefits over cost of about $7,800. Therefore, the structure floodproofing and removal alternative, as described herein, would be both a technically sound and economically feasible means of abating flood damages in the Underwood Creek flood-prone area of the City of Brookfield.

For the Butler Ditch flood-prone area, and as shown on Map 26, the analyses indicated that there were no structures that would have to be removed from the 100-year recurrence interval floodlands under this alternative, but that a total of about 20 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damages to private residences would be virtually eliminated by the floodproofing and removal. Table 27 sets forth a schedule of the approximate number of structures to be floodproofed and also summarizes the estimated costs and benefits. The equivalent average annual cost of the structure floodproofing measure calculated, using an annual interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $400, consisting entirely of amortization of the $6,400 capital cost of the structure floodproofing. The average annual flood abatement benefit is estimated at about $2,300, yielding a benefit cost ratio of 5.75 and an excess of annual benefits over cost of about $1,900. Therefore, the structure floodproofing alternative, as described herein, would be both a technically sound and economically feasible means of abating flood damages in the Butler Ditch flood-prone area of the City of Brookfield.

Table 27

PRINCIPAL FEATURES AND COSTS AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE CITY OF BROOKFIELD

Underwood Creek Reach Between W. North Avenue and Pilgrim Road

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
				Capital Cost		Annual Amortization of Capital Cost	Annual Operation and Maintenance Cost	Total Annual Cost	Annual Benefit	Annual Benefit Minus Annual Cost	Benefit-Cost Ratio	Economically Feasible?			
Number	Name	Description		Item	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)			Positive	Negative	
1	No Action	--	Yes	--	--	--	--	74.4	0.0	- 74.4	0.00	No	--	--	No
2	Detention Storage	215 acre-feet detention reservoir on Dousman Ditch	Yes	Reservoir and associated works	115.9[e]	7.4[e]	1.1[e]	8.5[e]	37.7	29.2	4.44	Yes	1. Potential to retain public open space along Dousman Ditch primary environmental corridor	1. Resolve 44 percent of the flood problem 2. May encourage new flood-prone development	No
3	Structure Floodproofing and Removal	a. Floodproof up to 87 residential structures b. Remove up to 17 residential structures	Yes	Floodproofing Removal Subtotal	57.6 978.7 1,036.3	65.7	0.0	65.7	73.5	7.8	1.12	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries.	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	No
4	Channelization, Structure Floodproofing and Removal, and Bridge Alteration	a. 0.6 mile of major channelization b. Floodproof up to 44 residential structures c. Remove up to 2 residential structures d. Replace 2 stream crossings	Yes	Channelization Floodproofing Removal Bridges Subtotal	590.7 14.5 156.8 236.3 998.3	63.3	0.3	63.6	73.5	9.9	1.16	Yes	1. Floodproofing component permits some immediate partial flood relief at discretion of property owners 2. With floodproofing component, some costs could be borne by beneficiaries	1. Complete, voluntary implementation of floodproofing unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur 4. Nonaesthetic impact of channelization component in residential areas 5. Cannot be undertaken unilaterally by the City of Brookfield.	No
5	Dikes and Floodwalls Structure Floodproofing and Removal and Bridge Alteration	a. 1.44 miles of dike b. 0.12 miles of floodwall c. Floodproof up to 7 residential structures d. Replace 2 stream crossings e. Install 5 stormwater pumping stations	Yes	Dikes Floodwalls Floodproofing Bridges Pumps Subtotal	451.9 118.3 1.5 368.0 325.0[f] 1,264.7	80.2	7.0	87.2	73.5	- 13.7	0.84	No	--	--	No
6	Bridge Alteration or Replacement	Replace 2 bridges causing backwater in excess of one foot	No	--	--	--	--	--	--	--	--	--	--	--	No
7	Detention Storage, Bridge Alteration, and Floodproofing and Removal	a. 215 acre-feet detention reservoir b. Floodproof up to 65 residential structures c. Remove up to 7 residential structures d. Replace the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge	Yes	Reservoir Floodproofing Removal Bridges Subtotal	115.9 41.0 352.6 210.0 719.5	45.6	1.1	46.7	73.5	26.8	1.57	Yes	1. Potential to retain public open space along Dousman Ditch primary environmental corridor 2. Floodproofing component permits some immediate partial relief at discretion of property owner 3. With floodproofing component, some costs could be borne by beneficiaries	1. Complete, voluntary implementation of floodproofing unlikely and therefore left with a residual flood problem 2. Overland flooding and some attendant problems remain in floodproofed areas 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	Yes

Butler Ditch Reach Between Lisbon Road (River Mile 1.02) and River Mile 2.28

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
				Capital Cost		Annual Amortization of Capital Cost	Annual Operation and Maintenance Cost	Total Annual Cost	Annual Benefit	Annual Benefit Minus Annual Cost	Benefit-Cost Ratio	Economically Feasible?			
Number	Name	Description		Item	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)			Positive	Negative	
1	No Action	--	Yes	--	--	--	--	2.3	0.0	- 2.3	0.00	No	--	--	No
2	Structure Floodproofing	Floodproof up to 20 residential structures	Yes	Floodproofing	6.4	0.4	0.0	0.4	2.3	1.9	5.75	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Upstream storage may encourage new flood-prone development 2. Complete, voluntary implementation of floodproofing unlikely and therefore left with a significant residual flood problem 3. Overland flooding and some attendant problems remain 4. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	Yes

[a] Economic analyses are based on an annual interest rate of 6 percent and assume a 50 year amortization period and project life.

[b] A preliminary technical and economic assessment of temporary storage in mined chambers beneath the watershed indicated that while this would be technically feasible it would be an extremely uneconomic means of resolving flood problems in all or portions of the watershed. Minor channelization was judged to be technically impractical based on the results of an analysis of Underwood Creek in the Village of Elm Grove.

[c] Economic analyses were not done for technically impractical alternatives.

[d] Presented only for technically and economically feasible alternatives.

[e] Based on the assumption that the total average annual cost of $46,200 for the detention reservoir would be shared by the Village of Elm Grove and the City of Brookfield in proportion to the flood damage mitigation benefits derived by each community.

[f] Present worth cost based on a 25 year economic life.

Source: SEWRPC.

Map 26

STRUCTURE FLOODPROOFING ALONG BUTLER DITCH IN THE CITY OF BROOKFIELD

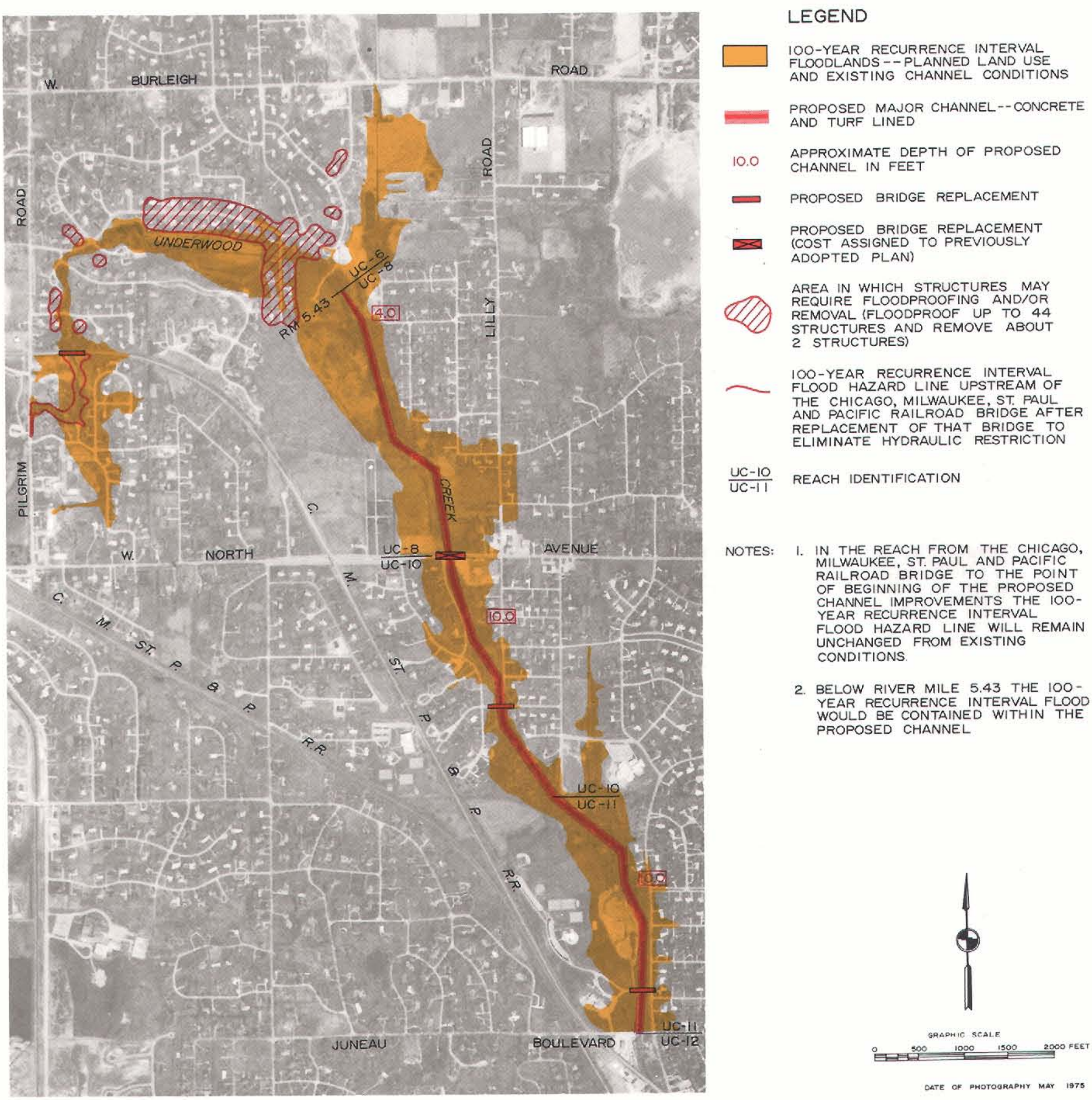
Structure floodproofing was determined to be a technically and economically feasible solution to existing and forecast flood problems along the short reach of Butler Ditch immediately west of Lilly Road in the City of Brookfield. This measure, which would require the floodproofing of up to 20 residential structures, was recommended for inclusion in the watershed plan.

Source: SEWRPC.

Channel Modifications, Structure Floodproofing and Bridge Alteration: As shown on Map 27, the channelization component of this alternative would extend from River Mile 5.43—approximately 0.16 mile downstream of the Clearwater Drive crossing of Underwood Creek—downstream to the City of Brookfield-Village of Elm Grove boundary at W. North Avenue (River Mile 4.82) where it would join a major channel improvement beginning at that point and extending down through the Village of Elm Grove. The channelization portion of this alternative assumes that a major channel modification project will be carried out in the Village of Elm Grove with the following channelization costs being assigned to the City of Brookfield: the entire cost of the channelization within the City of Brookfield plus the incremental cost associated with the additional channel depth that would be required in the Village of Elm Grove in order to provide an adequate channel grade at the City of Brookfield-Village of Elm Grove line. The channelization component of this alternative was not extended farther upstream along Underwood Creek in Brookfield because of the steep channel grades which exist along the Creek upstream of Clearwater Drive, which would necessitate the use of many costly channel drop structures, and because of the very close proximity of the residential structures to Underwood Creek, particularly along that reach extending from approximately San Gabriel Drive extended upstream to Pilgrim Road. The channelization was designed to pass the 100-year recurrence interval discharge under year 2000 land use plan conditions without overtopping. The modified channel would be located along the alignment of Underwood Creek in the City of Brookfield and in the Village of Elm Grove. The channel bottom profile and channel cross-sectional shape at the upstream end of the channelized reach would be designed so as to effect an acceptable transition to the existing natural channel grade and shape. Proceeding in a downstream direction, the channelization would lower the existing Underwood Creek channel by about four feet at Ridgewood Road extended (River Mile 5.35), about four and one-half feet at Ivy Lane extended (River Mile 5.13), about five feet at the

Map 27

MAJOR CHANNEL WORKS, STRUCTURE FLOODPROOFING AND REMOVAL, AND BRIDGE MODIFICATION ALONG UNDERWOOD CREEK IN THE CITY OF BROOKFIELD



This alternative consists of a combination of measures intended to resolve existing and forecast flood problems along Underwood Creek in the City of Brookfield. This approach was shown to be technically practicable and economically feasible and, therefore, was one of the several measures considered in formulation of floodland management recommendations for the Brookfield-Elm Grove area.

Source: SEWRPC.

Brookfield-Elm Grove line (River Mile 4.82), about five and one-half feet at Underwood River Parkway extended (River Mile 4.40), and about six feet at Elmhurst Parkway extended (River Mile 3.99). The width of the invert or bottom of the concrete channel within the City of Brookfield would be 20 feet and the side slopes would be one vertical on three horizontal. The bottom and side walls up to the 10-year flood stage would be lined with concrete, resulting in a total concrete width of from 25 to 35 feet within Brookfield.

The channelization would require demolition and replacement of the existing bridge at the W. North Avenue crossing of Underwood Creek. The cost of reconstructing this crossing, however, was not charged against the channelization-floodproofing-bridge alteration alternative since the structure is recommended for improvement in the adopted jurisdictional highway system plan for Waukesha County in order to provide adequate traffic capacity.

The structure floodproofing component of this alternative would be applied along Underwood Creek beginning in the vicinity of Clearwater Drive crossing at River Mile 5.59 and extending upstream to the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 6.32. As shown on Map 27, the analyses indicated that two structures may have to be removed from the 100-year recurrence interval floodlands while a total of about 44 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damages to private residences would be abated in this reach by the application of floodproofing and removal.

Modification of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 6.32 was included as an integral part of this alternative because hydraulic computations indicate that the bridge constitutes a significant obstruction to flow—this crossing produces a backwater effect of approximately 18 feet under year 2000 plan—100-year recurrence interval discharge conditions—and because the close proximity of residential structures to Underwood Creek in this area render the construction of major channel works impractical since such construction would actually require removal of the structures that are to be protected. The railroad bridge would be altered by providing an enlarged waterway opening that would pass the 100-year recurrence interval discharge under year 2000 plan conditions with the maximum head loss of 0.5 feet.

The technical practicality and economic feasibility of a local bypass of Underwood Creek was examined as a potentially more cost-effective method of resolving the flood problems in the Underwood Creek reach bounded by Pilgrim Road and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge. The bypass would consist of an open channel parallel to and west of Pilgrim Road extending from the intersection of Underwood Creek and Pilgrim Road approximately 950 feet in a northerly direction to the Chicago, Milwaukee, St. Paul, and Pacific Railroad. At this point, there would be a transition to a large conduit that would pass beneath the railroad grade, turn east and pass beneath Pilgrim Road, and extend easterly approximately 520 feet to join Underwood Creek immediately downstream of the railroad crossing of the Creek. As shown on Map 29, this facility would permit the diversion of the 100-year recurrence interval flood flow under year 2000 plan conditions of 1,940 cfs past the flood-prone Underwood Creek reach between Pilgrim Road and the Chicago, Milwaukee, St. Paul, and Pacific Railroad but could be designed so that moderate stream flows could be maintained through the existing channel in this reach for aesthetic purposes. The open channel portion of this alternative would have a bottom width of 20 feet, side walls with a one-on-three slope, and the bottom and the side slopes up to the 10-year recurrence stage would be lined with concrete. The conduit portion of this subalternative would consist of 600 feet of 7.5-feet-diameter concrete conduit having an upstream invert elevation of about 810.2 feet above Mean Sea Level Datum and a downstream invert elevation of about 794.5 feet above Mean Sea Level Datum for a total drop, and therefore available hydraulic head, of 15.7 feet.

The capital cost of the open channel component of the bypass subalternative is estimated at $131,000 and the capital cost for the conduit component would be $402,000, including allowance for a support structure where the conduit passes beneath the Chicago, Milwaukee, St. Paul, and Pacific Railroad, giving a total capital cost of $533,000 for the bypass subalternative. This capital cost is approximately 2.5 times the $210,000 capital cost of reconstructing the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge over Underwood Creek. It is apparent that the reconstruction of that bridge is a more cost-effective way of solving the flood problem in the Underwood Creek reach between Pilgrim Road and the railroad bridge and, therefore, the bypass subalternative did not receive further consideration in the development of floodland management alternatives for Underwood Creek in the City of Brookfield.

A schedule of the physical characteristics of the major channelization-floodproofing-bridge replacement alternative and the attendant costs and benefits is presented in Table 27. The equivalent average annual cost of the alternative calculated, using an annual interest rate of 6 percent and project life and amortization period of 50 years, is estimated at about $63,600 consisting of: $39,100 for amortization of the $617,000 capital cost of the channel modification and associated bridge replacement, $900 for amortization of the $14,500 capital cost of structure floodproofing, $10,000 for amortization of the $156,800 capital cost of structure removal, $13,300 for amortization of the $210,000 capital cost of demolition and reconstruction of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge, and $300 annual operation and maintenance costs. Assuming that the major channelization-floodproofing-bridge alteration alternative would completely eliminate all direct and indirect flood damages along Underwood Creek between Pilgrim Road and W. North Avenue in the City of Brookfield, the average annual flood abatement benefit is estimated at about $73,500, yielding a benefit-cost ratio of 1.16 and an annual excess of benefits over costs of about $9,900. Therefore, the channelization-floodproofing-bridge alteration alternative may be considered a technically practicable and economically viable means of abating flood damages in the flood-prone reach along Underwood Creek in the City of Brookfield.

Another factor to be considered in the evaluation of this alternative is that it could not be undertaken unilaterally by the City of Brookfield inasmuch as technical feasibility requires that the channel modifications extend downstream into the Village of Elm Grove in order to effect an acceptable transition to the existing channel grade. In the event that the Village of Elm Grove does not undertake the channel modifications, the City of Brookfield would be faced with the problem of securing permission from the Village of Elm Grove to extend channelization into the Village and would also be faced with the responsibility of absorbing not only the cost of channel improvements within Brookfield but also the entire cost of that portion extending downstream into the Village of Elm Grove.

A major channelization alternative was not developed for the Butler Ditch flood-prone reach in the City of Brookfield. Relative to most other flood-prone reaches, average annual damages per mile of riverine area are small in the Butler Ditch reach and therefore it was apparent that a costly structural measure like major channel works would not be economically feasible.

Dikes and Floodwalls, Structure Floodproofing and Bridge Alteration: As shown on Map 28, the dike-floodwall component of this alternative would be limited to the river reach extending from River Mile 5.95 downstream to the City of Brookfield-Village of Elm Grove boundary at W. North Avenue (River Mile 4.82). Under this alternative, a total of 1.56 miles of earthen dikes and concrete or sheet steel floodwalls similar to those shown in Figure 15 would be constructed along both sides of Underwood Creek. About 1.44 miles of earthen dike and about 0.12 miles of concrete or sheet steel floodwall would be required. In order to convey the design flood flow with a minimum freeboard of two feet, the dikes and floodwalls would be up to seven feet high in some locations. The dike-floodwall system would require construction of a new bridge at the Clearwater Drive crossing of Underwood Creek (River Mile 5.59) in order to contain the floodwaters within the confines of the dikes and floodwalls. In addition, the dike-floodwall component of this alternative would include provision for construction of a minimum of five major storm water lift or pumping stations and backwater gates near the end of storm sewer outfalls or other drainageways that are tributary to Underwood Creek. These facilities would be required to prevent movement of floodwaters from the River to the surrounding urban areas through the storm sewers and drainageways and to prevent any accumulation of lateral runoff behind the dikes and floodwall creating local drainage problems.

The structure floodproofing component of this alternative would be applied along Underwood Creek beginning at about River Mile 6.0 and extending upstream to the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 6.32. As shown on Map 28, the analyses indicate that there would be no structures that would have to be removed from the 100-year recurrence interval floodlands while a total of about seven structures located in the secondary flooding zones may require some form of floodproofing. Future flood damages to private residences would be abated in this reach by application of floodproofing.

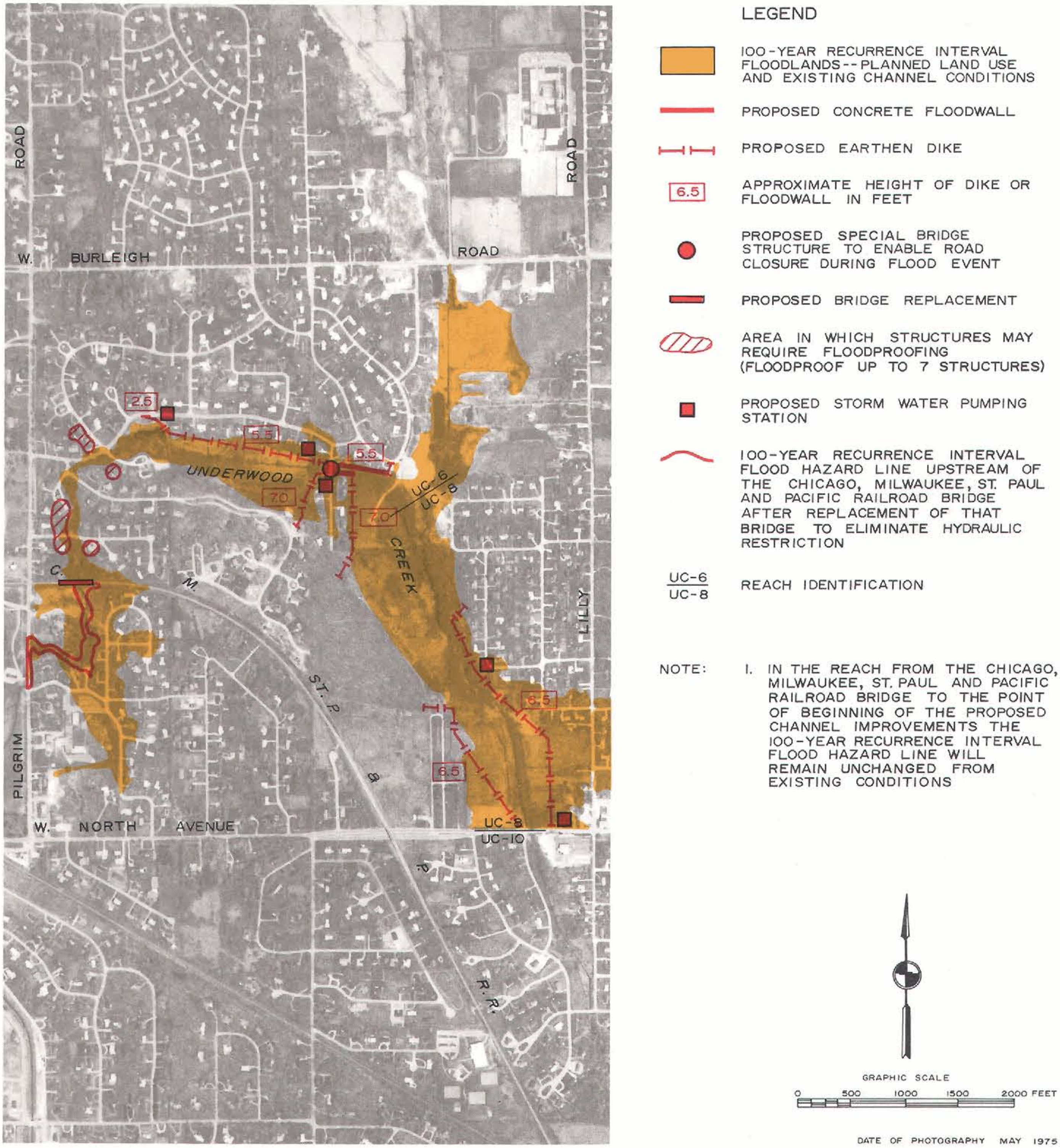
Modification of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 6.32 was included as an integral part of this alternative because, as already noted, hydraulic computations indicate that the bridge constitutes a significant obstruction to flow—this crossing produces a backwater effect of approximately 18 feet under year 2000 plan-100-year recurrence interval discharge conditions—and because the close proximity of residential structures to Underwood Creek in this area render the construction of dikes and floodwalls impractical since such construction would actually require removal of some of the structures that are to be protected. The railroad bridge would be altered by providing an enlarged waterway opening that would pass the 100-year recurrence interval discharge under year 2000 plan conditions with a minimum backwater of 0.5 feet. It may be necessary under this alternative to supplement replacement of the railroad bridge with selected floodproofing of structures along Underwood Creek in the reach bounded at the downstream end by the railroad bridge and at the upstream end by Pilgrim Road. The cost of that floodproofing was not included in the economic analyses because it was determined that those costs would be very small compared to the cost of reconstructing the railroad bridge and would not, therefore, significantly influence the outcome of the benefit cost analysis.

The schedule of the physical characteristics of this alternative and the attendant costs and benefits is presented in Table 27. The equivalent average annual cost of the dike and floodwall-bridge alteration alternative, calculated using an annual interest rate of 6 percent and at a project life and amortization period of 50 years, is estimated at $87,200 consisting of the following: $36,200 for amortization of the $570,200 capital cost of the dikes and floodwalls and land necessary to construct them, $23,300 for amortization of the $368,000 capital cost of the new river crossings, $20,600 for amortization of the $325,000 capital cost of the backwater control and pumping facilities, $100 for amortization of the $1,500 capital cost of floodproofing, and $7,000 for annual operation and maintenance costs. Assuming that the dike and floodwall-bridge alteration project would completely eliminate all direct and indirect flood damage along Underwood Creek in the City of Brookfield between Pilgrim Road and W. North Avenue, the average annual abatement benefit is estimated at about $73,500, yielding a benefit-cost ratio of 0.84 and an annual excess of costs over benefits of about $13,700. Therefore, the dike and floodwall-bridge alteration plan element as described herein may be considered technically practicable, but it is not economically feasible for the flood-prone reaches along Underwood Creek in the City of Brookfield.

A dike-floodwall alternative was not developed for the Butler Ditch flood-prone reach in the City of Brookfield. Relative to most other flood-prone reaches, average annual damages per mile are small in the Butler Ditch

Map 28

DIKE-FLOODWALL SYSTEM, STRUCTURE FLOODPROOFING, AND BRIDGE MODIFICATION ALONG UNDERWOOD CREEK IN THE CITY OF BROOKFIELD



This alternative measure for abating existing and probable future flood problems along Underwood Creek in the City of Brookfield consists of selective use of earthen dikes and concrete floodwalls and of structure floodproofing supplemented with removal of the hydraulic constriction imposed by the existing Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and with storm water pumping facilities. While technically practicable, this alternative was shown to be economically unfeasible.

Source: SEWRPC.

reach and, therefore, it was apparent that a costly structural measure like major channel works would not be economically feasible.

Bridge or Culvert Alteration or Replacement for Flood Control Purposes: The removal or alteration of selected bridges or culverts on Underwood Creek and Butler Ditch in the City of Brookfield—other than the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and other crossings included with the channelization dike floodwall alternatives—was examined as a potential means of reducing the flood problems in the reaches immediately upstream of such crossings. Bridges and culverts in these reaches producing backwater effects in excess of one foot under year 2000 plan-100-year recurrence interval discharge conditions were identified to determine if a reduction in backwater would be a technically and economically feasible means of resolving a substantial portion of flood problems. Two crossings were found to exist in this category along the Underwood Creek flood-prone reaches and none on the Butler Ditch flood-prone reach. The Santa Maria bridge at River Mile 5.99 on Underwood Creek produces a backwater of about two feet and the Indian Creek Parkway bridge at River Mile 6.20 produces a backwater of about 2.5 feet. Removal or modification of these structures so as to essentially eliminate the backwater effect would reduce local floodstages over a very short reach—about 0.1 mile—and, therefore, monetary flood risks would not be significantly reduced throughout the Underwood Creek flood-prone reach. Consequently this alternative was deemed to be not technically practicable and further analyses of alteration or replacement of these two Underwood Creek crossings not warranted.

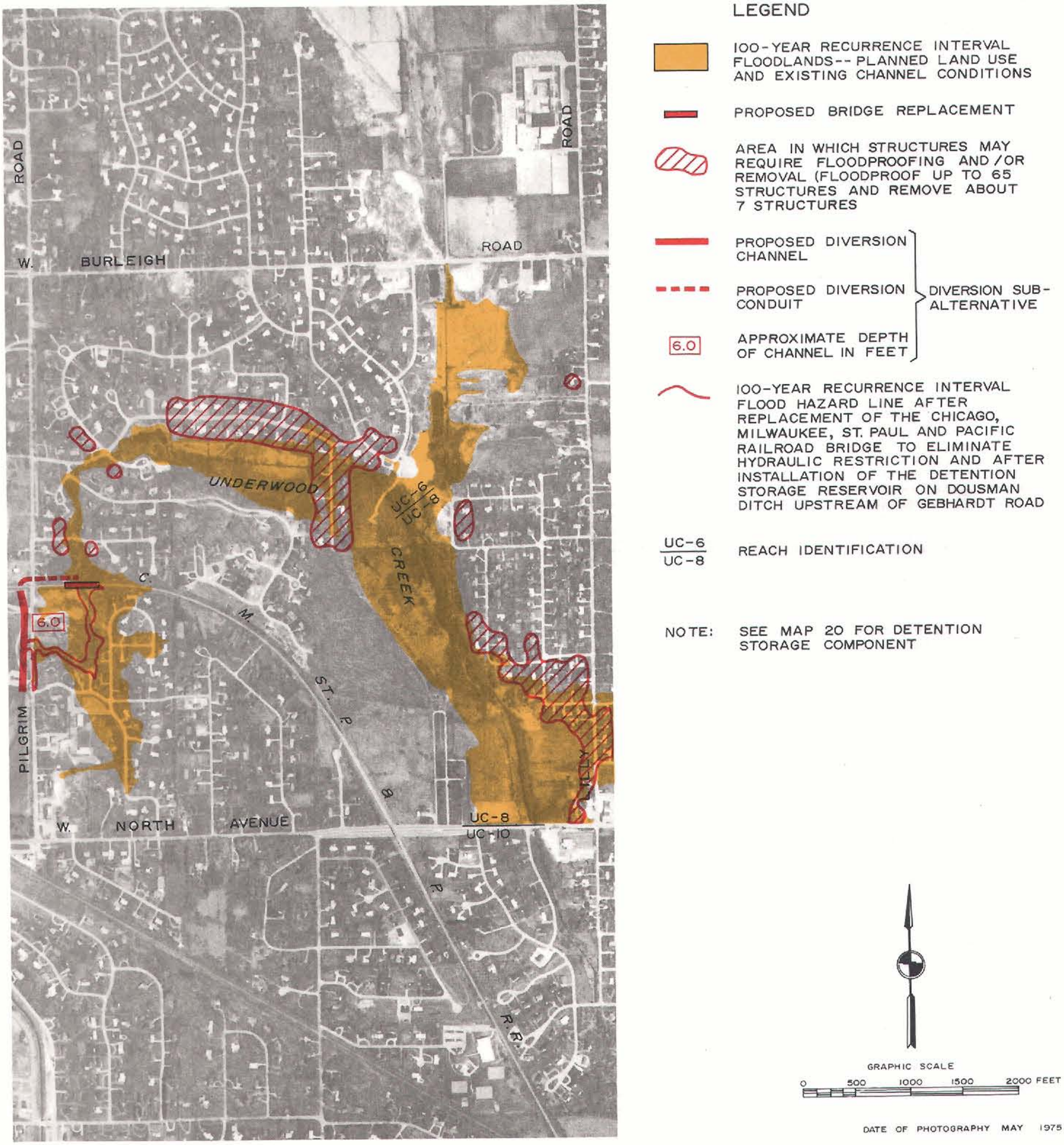
Detention Storage, Bridge Alteration, and Structure Floodproofing and Removal: Although detention storage would abate only about one-half of the flood problem along Underwood Creek in the City of Brookfield, as measured by the reduction in average flood damages, this measure does exhibit very favorable cost benefit features in that an average annual benefit of approximately $36,000 would be achieved with an average annual cost assignable to Brookfield for the detention reservoir of approximately $8,500, which would represent its share of the total annual cost of $46,200 for the reservoir. The costs of the reservoir were assigned on the assumption that the total average annual costs of $46,200 would be shared by the Village of Elm Grove and the City of Brookfield in proportion to the flood damage mitigation benefits derived in each community, namely $36,000 per year in Brookfield and $160,000 per year in Elm Grove. Therefore, in order to use the very favorable benefit-cost features of the detention reservoir, another alternative was developed for abating flood damages along Underwood Creek in the City of Brookfield consisting of three components: an upstream detention storage on Dousman Ditch at Gebhardt Road; replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge; and structure floodproofing and removal along the 1.51-mile-long reach of Underwood Creek bounded by the railroad bridge on the upstream end and North Avenue on the downstream end. As shown on Map 29, the analyses indicated that seven structures may have to be removed from the 100-year recurrence interval floodlands under this alternative, and a total of about 65 structures located in the primary and secondary flood zones may require some form of floodproofing. This compares with the removal of 17 structures and the floodproofing of up to 87 structures would be required under the structure floodproofing and removal alternative discussed above.

The equivalent average annual cost of the detention storage-bridge replacement-floodproofing alternative, calculated using an annual interest rate of 6 percent and a project life of amortization period of 50 years, is estimated at about $46,700, consisting of $8,500 per year assignable to the City of Brookfield for amortization of the capital costs and for the operation and maintenance of the upstream detention reservoir; $13,300 per year for amortization of the $210,000 capital cost of replacing the railroad bridge; $2,600 per year for amortization of the $41,000 capital cost of structure floodproofing; and $22,300 for amortization of the $352,600 capital cost of structure removal. The costs of the reservoir were assigned on the assumption that the total average annual costs of $46,200 for the detention reservoir would be shared by the Village of Elm Grove and the City of Brookfield in proportion to the flood damage mitigation benefits derived by each community which would total $36,000 per year in the City of Brookfield and $160,000 per year in the Village of Elm Grove. Future flood damages to private residences would be virtually eliminated by this alternative and the resulting average annual flood abatement benefit is estimated at about $73,500, yielding a benefit-cost ratio of 1.57 and an excess annual benefit over annual cost of about $26,800. Therefore, the detention storage-bridge replacement-structure floodproofing and removal alternative, as described herein, would be both technically feasible and economically viable for the Underwood Creek flood-prone area within the City of Brookfield. In the event that the Village of Elm Grove would not participate in financing the upstream detention reservoir, the equivalent average annual costs incurred by the City of Brookfield would increase to about $84,400, consisting of the amortization of the $210,000 capital cost of replacing the railroad bridge and the amortization of the $393,600 capital cost of structure floodproofing and removal plus the entire $46,200 annual cost of the upstream detention reservoir. The average annual flood abatement benefit would remain at $73,500, yielding a benefit cost ratio of 0.87 and an excess of annual cost over benefits of about $10,900. Therefore, the detention storage and structure floodproofing alternative, as described herein, would be both technically and economically feasible for the Underwood Creek flood-prone area within the City of Brookfield only if the Village of Elm Grove participates in financing the upstream detention reservoir.

In order to identify the most cost-effective means of eliminating the flood problem in the short reach of Underwood Creek between Pilgrim Road and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge, an analysis was made of the economics of a subalternative in that reach consisting of structure floodproofing and removal in lieu of replacement of the railroad bridge. The increase in capital cost associated with structure floodproofing and

Map 29

DETENTION STORAGE, BRIDGE MODIFICATION, AND STRUCTURE FLOODPROOFING AND REMOVAL ALONG UNDERWOOD CREEK IN THE CITY OF BROOKFIELD



This alternative floodland management measure combines the best features of other alternatives examined for the purpose of resolving existing and forecast flood problems along Underwood Creek in the City of Brookfield. It is recommended that this combination of detention storage, bridge modification, and structure floodproofing and removal be implemented in the City of Brookfield in combination with floodproofing and intermediate and major channel improvements downstream along Underwood Creek in the Village of Elm Grove.

Source: SEWRPC.

removal in this reach was determined to be $211,900, whereas the reduction in capital cost associated with elimination of the need for replacing the railroad bridge was determined to be $210,000, for a net increase in capital cost of $1,900. Based on the results of this economic investigation, reconstruction of the railroad bridge is more cost-effective than structure floodproofing and removal for resolving the flood problems in the Pilgrim Road-railroad bridge reach of Underwood Creek.

Concluding Statement: Five distinctly different structural floodland management alternatives—storage in a detention reservoir, major channelization supplemented with structure floodproofing and removal and bridge alteration, a dike-floodwall system supplemented with structure floodproofing and bridge alteration, bridge alteration or replacement, and a storage-floodproofing bridge replacement- and removal combination—and one nonstructural measure—a combination of structure floodproofing and structure removal—were examined as possible solutions to the flood problems that exist along Underwood Creek in the City of Brookfield. In addition, a seventh alternative, that of taking no action, is available to the public agencies concerned, and the flood damages attendant to this alternative provided an important basis for the analyses of the potential benefits associated with each of the other alternatives.

The principal features of and the costs and benefits associated with each of the floodland management alternatives for both Underwood Creek and Butler Ditch flood-prone areas are summarized in Table 27 together with the major favorable and unfavorable nontechnical and noneconomical considerations likely to influence selection of the most desirable solution. In addition to the alternatives identified in the table, the diversion of floodwaters to Lake Michigan and the temporary storage of waters in mined storage chambers beneath the watershed were subjected to a preliminary assessment; although these two alternatives were determined to be technically feasible, both were shown to be economically unsound by a wide margin.

All of the structural and nonstructural alternatives examined in detail for the Underwood Creek reach were found to be technically feasible with the exception of bridge alteration or replacement. Of the remaining five measures, four were found to be both technically practicable and economically feasible—detention storage, structure floodproofing and removal, major channelization supplemented with structure floodproofing and removal and bridge alteration, and the storage-floodproofing and removal-bridge alteration composite.

The alternative involving only upstream detention storage was eliminated from further consideration. Even though this alternative exhibits very favorable benefit-cost features, it would only eliminate about 45 percent of the flood problem along Underwood Creek between W. North Avenue and Pilgrim Road. The alternative involving only structure floodproofing and removal, although technically and economically feasible for this reach of Underwood Creek, was eliminated from further consideration for four important reasons. First, complete implementation of voluntary structure floodproofing and removal program is unlikely and, with partial implementation, the City of Brookfield would be left with a significant residual flood problem whenever a major flood event occurs. In spite of the fact that numerous individual property owners may have implemented floodproofing and have incurred the necessary costs, community officials may still be faced with the problem of reducing the flood threat to those structures that have not been voluntarily floodproofed. Second, other viable alternatives are available, which could be applied with significantly higher likelihood of success in eliminating most of the Underwood Creek flood problems. Third, even if the voluntary structure floodproofing program were completely carried out, extensive overland flooding would still occur thereby, hampering the access to and from some riverine area structures, periodically closing local streets to automobile traffic, and interfering with the rapid movement of emergency vehicles. Furthermore, yard and street damages and cleanup costs would remain with the structure floodproofing and removal alternative. Fourth, some floodproofing is very likely to be applied without adequate professional advice and, as a result, structure damage is likely to occur, and once again City officials are likely to be asked to assist in the resolution of the problem.

The alternative involving major channel modification supplemented with structure floodproofing and removal and bridge alteration was eliminated from further consideration because the economic features of this alternative—annual benefit minus annual cost of $9,900 and a benefit-cost ratio of 1.16—are significantly less attractive than the economic features of the fourth and last technically practicable and economically feasible alternative involving storage, bridge replacement, and structure floodproofing and removal which has an annual excess of benefits over cost of $26,800 and a benefit-cost ratio of 1.57.

After due consideration of the various technical and economic features and other aspects of the storage and floodproofing alternative, it is recommended that upstream storage on Dousman Ditch in combination with replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and structure floodproofing and removal be employed to resolve existing and forecast flood problems along Underwood Creek in the City of Brookfield. This alternative is recommended even if the Village of Elm Grove elects not to participate in the funding of the Dousman Ditch detention storage area which would render this alternative slightly uneconomic from a strictly flood control perspective. Development of a detention reservoir along Dousman Ditch in the City of Brookfield is fully consistent with preservation of the primary environmental corridor along the Dousman Ditch inasmuch as it would provide a mechanism—in addition to the use of floodland and conservancy zoning, as recommended in the land use plan element—for maintaining the area in public open space use.

The only economically feasible means of reducing the secondary flooding problem that exists in the City of Brookfield along Butler Ditch is structure floodproofing.

Although floodproofing has significant negative features as identified in Table 27, and as discussed above, it is the only means available for achieving relief from secondary flooding and is recommended for the Butler Ditch reach. More specifically, it is recommended that floodproofing be applied to residential structures in the primary and secondary flooding zones along Butler Ditch that are not subject to first floor inundation by the 100-year recurrence interval flood under year 2000 plan conditions. These residential structures should be floodproofed to an elevation two feet above the 100-year recurrence interval flood stage. Inasmuch as the 100-year flood stage is below the first floor elevation of all residential structures in this reach, there are no structures recommended for removal. It is imperative that all floodproofing measures be applied under the guidance of a registered engineer. Failure to utilize adequate professional supervision is likely to result in damage to the structure during a major flood.

The Village of Menomonee Falls

The Flood Problem: As shown on Map 15, the Village of Menomonee Falls contains four flood-prone reaches of the Menomonee River watershed stream system. Three of these reaches are located along the main stem of the Menomonee River and have a combined length of 3.13 miles or approximately half the total length of the Menomonee River within the Village of Menomonee Falls. The fourth flood-prone reach is located along Lilly Creek between its confluence with the Menomonee River and the Chicago and Northwestern Railroad crossing at River Mile 2.59, with most of the damage in this reach being concentrated in the residential area bounded at the downstream end by W. Good Hope Road at River Mile 0.84 and extending upstream approximately 0.58 miles to about Jerry Lane extended at River Mile 1.42.

For the Village as a whole, average annual monetary flood risks attributable to both primary and secondary flooding under existing conditions are estimated at about $69,300, whereas the average annual monetary flood risks under year 2000 land use and floodland development conditions are estimated at about $145,700, a 110 percent increase over existing conditions. It should be emphasized that the increase in average annual monetary damages under year 2000 plan conditions is attributed solely to anticipated changes in land use development in upstream portions of the watershed inasmuch as the analysis presumes that no new flood-prone structures will be constructed in the Village of Menomonee Falls. As discussed earlier in this chapter, complete development of the floodland and nonfloodland portions of the watershed that are tributary to the Menomonee River and Lilly Creek in the Village of Menomonee Falls could be expected to be resolved in an approximately six-fold increase in average annual damages. If additional flood-prone development were permitted within the Village of Menomonee Falls, even higher monetary risks would be incurred. As a result of direct and indirect damages associated with the flooding of the Menomonee River and Lilly Creek, the Village may be expected to incur about $376,700 in flood damages during a 100-year recurrence interval flood under existing conditions and damages of about $515,200 under year 2000 plan conditions.

For analytic purposes, each of four flood-prone reaches within the Village of Menomonee Falls was treated individually. This approach was employed primarily because the four reaches are separated from each other, giving rise to the possible technical feasibility of applying different approaches in each of the reaches.

Floodproofing and Removal of Structures: A structure floodproofing and removal alternative was developed and analyzed for each of the four flood-prone reaches within the Village of Menomonee Falls to determine if a structure-by-structure approach would constitute a technically feasible, economically sound, and environmentally acceptable solution to the flood problem in the Village. The design criteria and overall approach used in this analysis were identical to those applied to the Village of Elm Grove flood problem. The floodproofing and removal alternative are shown on Map 30 and the approximate number and types of structures to be floodproofed and removed are set forth in Table 28 along with the attendant costs and benefits.

For that reach of the Menomonee River between County Line Road (CTH Q) at River Mile 23.47 and Main Street (STH 74) at River Mile 21.93, the analyses indicated that only two structures may have to be removed from the 100-year recurrence interval floodlands under this alternative, and up to about 59 structures located in the primary and secondary flooding zones would require some form of structure floodproofing. Future flood damages to private residences and commercial structures within this reach would be virtually eliminated by structure floodproofing and removal. The average annual cost of this alternative, computed using an interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $9,800, consisting entirely of amortization of the $47,700 capital costs of the structure floodproofing and the $107,900 capital cost of structure removal. The average annual flood abatement benefits are estimated at about $18,300, yielding a benefit-cost ratio of 1.87 and an excess of annual benefits over annual costs of about $8,500. Therefore, the structure flood-proofing and removal alternative would be both technically and economically feasible for this reach.

For that reach of the Menomonee River between Jacobson Drive extended at River Mile 21.65 and River Mile 21.25, which is located approximately 700 feet west of Pilgrim Road, the analyses indicated that up to about 25 structures located in the primary and secondary flooding zones would require some form of floodproofing. Future flood damages to private residences within this reach could be virtually eliminated by structure floodproofing and removal. The average annual cost of the structure floodproofing and removal measures, computed using an interest rate of 6 percent and project life and amortization period of 50 years, is estimated at about $700, consisting entirely of the amortization of the $10,900 capital cost of the structure floodproofing. The average annual flood abatement benefits are estimated at about $9,500 yielding a benefit-cost ratio of 13.6 and an excess of annual benefits over annual costs of about $8,800. Therefore, the structure floodproofing and removal alternative would be both technically and economically feasible for this reach.

Table 28

PRINCIPAL FEATURES AND COSTS AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE VILLAGE OF MENOMONEE FALLS

Menomonee River Between the Northern Village Limits and STH 74 and Between Arthur Avenue and the Eastern Limits of the Village

Alternative[b]				Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		
Number	Name	Description	Technically Feasible?	Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	Recommended?
1	Major Channel Modification as Proposed by Village	a. 4.00 miles of major channelization-turf-lined b. 0.60 miles of major channelization-concrete lined c. Replace 9 stream crossings	Yes	Turf channelization Concrete channelization Bridges	868.7 700.9 509.0								1. Consistent with Village commitment to channelization as reflected by the location, size, and grade of existing and proposed storm sewers	1. Aesthetic impact	Yes
				Subtotal	2,078.6	131.9	4.3	136.2	36.3	- 99.9	0.27	No			

Menomonee River Between Northern Village Limits and STH 74

Alternative[b]				Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		
Number	Name	Description	Technically Feasible?	Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	Recommended?
1	No Action	--	Yes	--	--	--	--	18.3	0.0	- 18.3	0.00	No	--	--	No
2	Structure Floodproofing and Removal	a. Floodproof up to 48 residential and 11 industrial structures b. Remove up to 2 residential structures	Yes	Floodproofing Removal	47.7 107.9								1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	No
				Subtotal	155.6	9.8	0.0	9.8	18.3	8.5	1.87	Yes			

Menomonee River Between Jacobson Drive Extended and 700 Feet West of Pilgrim Road

Alternative[b]				Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		
Number	Name	Description	Technically Feasible?	Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	Recommended?
1	No Action	--	Yes	--	--	--	--	9.5	0.0	- 9.5	0.00	No	--	--	No
2	Structure Floodproofing and Removal	Floodproof up to 25 residential structures	Yes	Floodproofing	10.9	0.7	0.0	0.7	9.5	8.8	13.60	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	No

Menomonee River Between Margaret Road Extended and Lilly Road

Alternative[b]				Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		
Number	Name	Description	Technically Feasible?	Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	Recommended?
1	No Action	--	Yes	--	--	--	--	8.5	0.0	- 8.5	0.00	No	--	--	No
2	Structure Flooproofing and Removal	a. Floodproof up to 33 residential structures b. Remove up to 1 residential structure	Yes	Floodproofing Removal	19.5 51.9								1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	No
				Subtotal	71.4	4.5	0.0	4.5	8.5	4.0	1.88	Yes			

Lilly Creek Between the Menomonee River and the Chicago and Northwestern Railroad

Alternative[b]				Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		
Number	Name	Description	Technically Feasible?	Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	Recommended?
1	No Action	--	Yes	--	--	--	--	109.4	0.0	- 109.4	0.00	No	--	--	No
2	Structure Floodproofing and Removal	a. Floodproof up to 82 residential and 8 industrial structures b. Remove up to 21 residential structures	Yes	Floodproofing Removal	73.3 1,180.0								1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	No
				Subtotal	1,253.3	79.5	0.0	79.5	109.4	29.9	1.38	Yes			
3	Major Channelization as Proposed by Village	a. 2.97 miles of major channelization b. Replace 7 stream crossings	Yes	Channelization Bridges	1,771.5 652.3								1. Consistent with the Village commitment to channelization as reflected by the location, size, and grade of existing and proposed storm sewers	1. Aesthetic impact	Yes
				Subtotal	2,423.8	156.0	2.2	158.2	109.4	- 48.8	0.69	No			
4	Bridge Alteration or Replacement	Alter or replace the Good Hope Road crossing	No	--	--	--	--	--	--	--	--	--	--	--	No

[a] *Economic analyses are based on an annual interest rate of 6 percent and assume a 50 year amortization period and project life.*

[b] *A preliminary technical and economic assessment of diversion of floodwaters from the watershed to Lake Michigan and temporary storage in mined chambers beneath the watershed indicated that while these would be technically feasible they would be extremely uneconomic means of resolving flood problems in all or portions of the watershed. A preliminary technical assessment of a system of 11 detention reservoirs revealed that such a system would not be a technically practical method for resolving flood problems within the Village of Menomonee Falls. Minor channelization was judged to be technically impractical based on the results of an analysis of Underwood Creek in the Village of Elm Grove.*

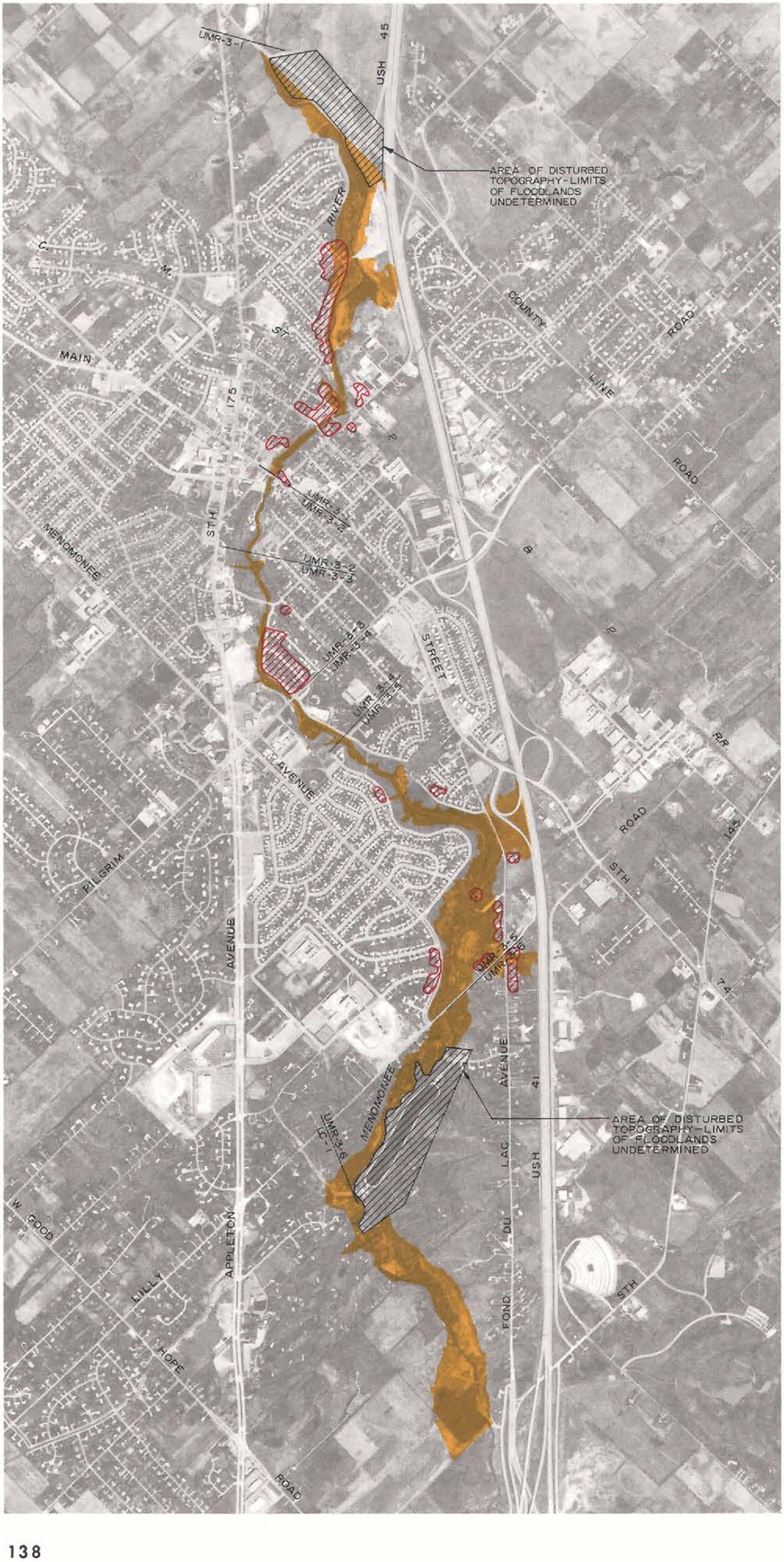
[c] *Economic analyses were not done for technically impractical alternatives.*

[d] *Presented only for technically and economically feasible alternatives with the exception of the channelization alternatives.*

Source: SEWRPC.

Map 30

STRUCTURE FLOODPROOFING AND REMOVAL ALONG THE MENOMONEE RIVER AND LILLY CREEK IN THE VILLAGE OF MENOMONEE FALLS



LEGEND

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

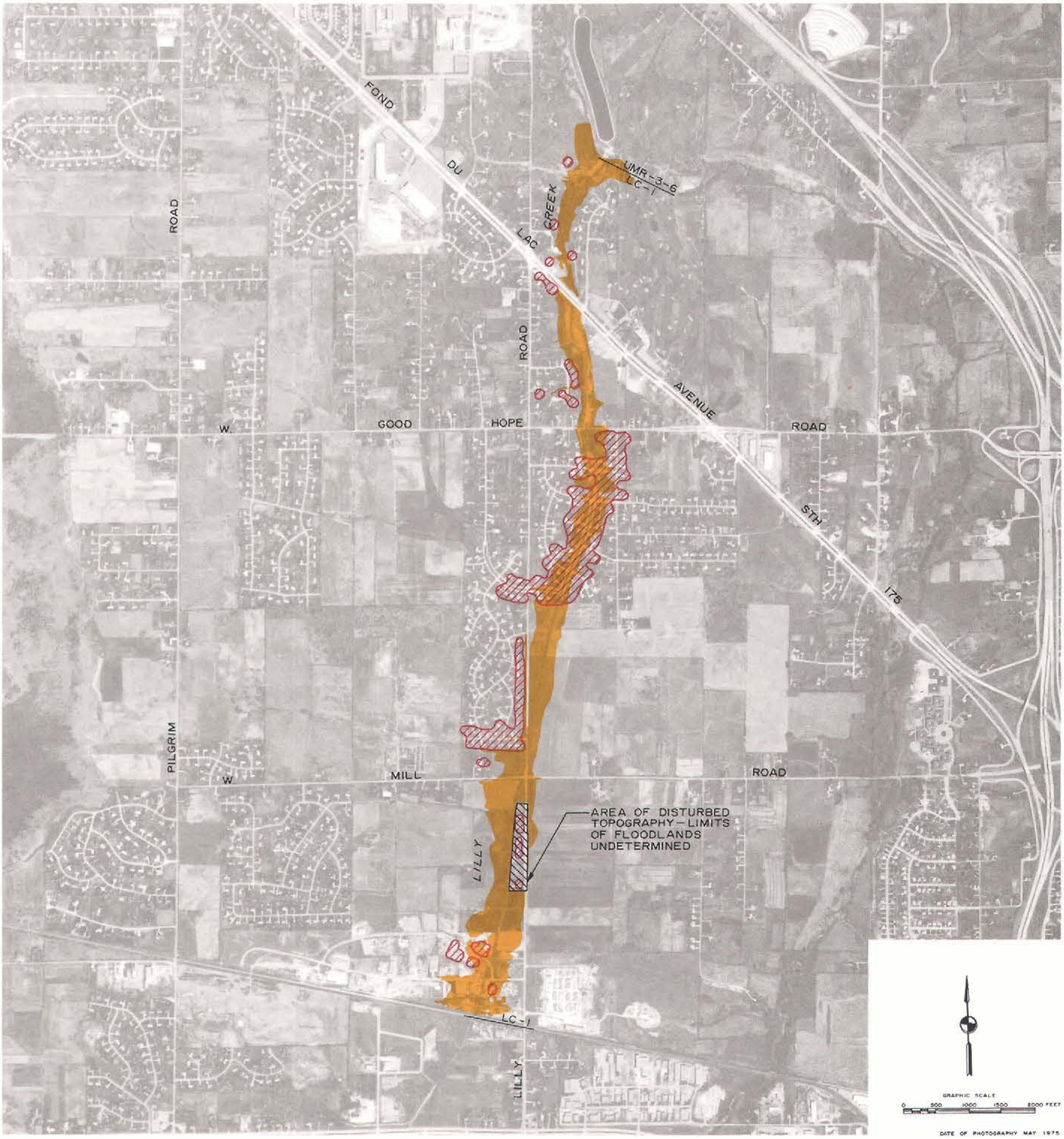
AREA IN WHICH STRUCTURES MAY REQUIRE FLOODPROOFING AND/OR REMOVAL (FLOODPROOF UP TO 207 STRUCTURES AND REMOVE ABOUT 24 STRUCTURES)

UMR-3-5 / UMR-3-6 REACH IDENTENTIFICATION

GRAPHIC SCALE
0 500 1000 1500 2000 FEET

DATE OF PHOTOGRAPHY: MAY 1975

Map 30—continued



Structure floodproofing and removal were examined as one alternative means of resolving the existing and probable future flood problems along portions of the main stem of the Menomonee River and along Lilly Creek within the Village of Menomonee Falls. Under this floodland management measure, up to 117 structures would be floodproofed and up to three structures would be removed along the Menomonee River while up to 90 structures would be floodproofed and up to 21 structures would be removed along Lilly Creek. This alternative was found to be an economically feasible solution to the flood problems.

Source: SEWRPC.

For the reach of the Menomonee River between Margaret Road extended at River Mile 20.93 and Lilly Road at River Mile 19.74 the analyses indicated that about one structure may have to be removed from the 100-year recurrence interval floodlands under this alternative and up to about 33 structures located in the primary and secondary flooding zones would require some form of floodproofing. Future flood damages to private residences within this reach would be virtually eliminated by structure floodproofing and removal. The average annual cost of the structure floodproofing and removal measures, computed using an interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $4,500, consisting entirely of amortization of the $19,500 capital costs of the structure floodproofing and the $51,900 capital cost of structure removal. The average annual flood abatement benefits are estimated at about $8,500, yielding benefit-cost ratio of 1.88 and an excess of annual benefits over annual costs of about $4,000. Therefore, the structure floodproofing and removal alternative would be both technically and economically feasible for this reach.

For the flood-prone reach of Lilly Creek between its confluence with the Menomonee River and the Chicago and Northwestern Railroad bridge at River Mile 2.59, the analyses indicated that about 21 structures may have to be removed from the 100-year recurrence interval floodlands under this alternative and up to about 90 structures located in the primary and secondary flooding zones would require some form of floodproofing. Future flood damages to private residences and commercial structures within this reach would be virtually eliminated by structure floodproofing and removal. The average annual cost of the structure floodproofing and removal alternative, computed using an interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $79,500, consisting entirely of the amortization of the $73,300 capital cost of the structure floodproofing and the $1,180,000 capital cost of removal. The average annual flood abatement benefits are estimated at about $109,400, yielding a benefit-cost ratio of 1.38 and an excess of annual benefits over annual cost of about $29,900. Therefore, the structure floodproofing and removal alternative would be both technically and economically feasible for this reach.

Locally Proposed Channel Modifications: The Village of Menomonee Falls has completed a preliminary design for the ultimate channelization of a major portion of the 5.52 mile length of the Menomonee River, extending from the Washington-Waukesha County line through the Village to the Waukesha-Milwaukee County line, and of the 3.00-mile-long reach of Lilly Creek extending from its confluence with the Menomonee River upstream to W. Silver Spring Drive.[6] This preliminary plan for the ultimate channelization of the Menomonee River and Lilly Creek was prepared in recognition of existing and likely future flood and stormwater drainage problems and in order to permit the proper design of the trunk sewer grades and alignments, street locations, and storm sewer outfall grades.

The alignment and grade of the proposed Menomonee River channel modifications were used to select the alignment and grade for the trunk sewer that parallels the Menomonee River and will ultimately connect the two Village sewage treatment plants to the Milwaukee-Metropolitan Sewerage Commissions' sewer system and treatment facilities. The ultimate channel grade was used to set the trunk sewer grade sufficiently low so that future sewers passing beneath the river and connecting to the trunk sewer would not have to be constructed as inverted siphons. The alignment and grade of the locally proposed ultimate channelization in the Village also were used to size and set grades for storm sewers discharging or planned to discharge at the following locations: on the Menomonee River at River Mile 22.80 near the River Court Shopping Center and at River Mile 21.00 and 20.72, near the Pilgrim Road sewage treatment plant, and along the entire length of Lilly Creek.

This tentative proposal for the ultimate channelization of the Menomonee River and Lilly Creek is pertinent to the floodland management element of the Menomonee River watershed plan inasmuch as the proposed channelization includes the four flood-prone reaches identified under the watershed study. The locally proposed channelization, in effect, constitutes one possible floodland management alternative that should be examined inasmuch as considerable effort has been expended by the Village Engineer in preparation of the proposal and the proposal is directed to the solution of existing and future flooding and storm water problems. Accordingly, the locally proposed channelization proposal, as shown on Map 31, was analyzed in order to determine if such a structural measure would, in accordance with the objectives and standards established under the watershed study, provide a technically feasible, economically sound, and environmentally acceptable solution to the existing and forecast flood and storm water problems in the Village.

For purposes of this analysis, the alignment, grade, and cross-section shape of the ultimate channel works as obtained from the Village of Menomonee Falls were used, with one substantive exception: the cross-section used in the analysis for the channel works on the 0.60-mile-long reach of the Menomonee River between Arthur Avenue and Margaret Road extended incorporates the use of a concrete lining for the channel bottom and the lower portion of the sidewalls because of the likelihood of erosion problems in this steeply sloped reach, whereas the locally proposed channel would be completely turf-lined in this reach.

In the flood-prone reaches, the proposed channel cross-section would be sized to contain the 100-year recurrence interval flood discharges under the year 2000 land use plan conditions with a two-foot freeboard. With the

[6] *This preliminary design is described in two reports—"Menomonee River Channelization Proposal" and "Lilly Creek Channelization Proposal"—prepared by Mr. Max A. Vogt, Village Engineer, Village of Menomonee Falls, May 12, 1976.*

exception of the above 0.60 mile reach of the Menomonee River and a 1.55 mile reach of Lilly Creek, the channel would be turf-lined since flood flow velocities would be less than a critical value of about five feet per second as a result of the relatively mild channel bottom slopes. The major channelization alternative for the Menomonee River and Lilly Creek in the Village of Menomonee Falls is shown on Map 31. A schedule of the physical characteristics of the major channel modifications and the attendant costs and benefits is set forth in Table 28.

Under this alternative, major channel improvements would be carried out over a total of 7.60 miles. The channel bottom profile and the channel cross-sectional shape at both the upstream and downstream ends of the Menomonee River portion and at the upstream end of Lilly Creek portion would be designed so as to effect an acceptable transition to the existing channel grade and shape. Proceeding in a downstream direction, channelization along the Menomonee River would lower the existing Menomonee River channel grade by about five feet at the private bridge at River Mile 22.72, about three feet at the Pilgrim Road crossing (River Mile 21.13), about three feet at the Lilly Road crossing (River Mile 19.74), and about two feet at the Menomonee River-Lilly Creek confluence (River Mile 18.98). The width of the invert or bottom of the channel along the Menomonee River within the Village of Menomonee Falls would be about 25 feet and side slopes would be about 25 feet; side slopes would be one on four, resulting in a channel top width ranging from approximately 70 to 120 feet wide. The channelization would require that the following nine bridges along the Menomonee River be replaced with structures which span the improved channel completely without obstructing the flow in any manner: a private bridge (River Mile 22.72), Roosevelt Drive (River Mile 22.11), Arthur Avenue (River Mile 21.48), Pilgrim Road (River Mile 21.13), Lilly Road (River Mile 19.74), three private pedestrian bridges (River Miles 18.95, 18.76, and 18.65), and a private bridge (River Mile 18.85). The demolition and reconstruction costs for all of the above structures would be charged to this alternative with the exception of three structures—Roosevelt Drive, Pilgrim Road, and Lilly Road—which are recommended for replacement under the adopted Jurisdictional Highway System Plan for Waukesha County. The channelization would also affect five private bridges (River Miles 22.17, 18.81, 18.73, 18.41, and 18.22) and two Chicago, Milwaukee, St. Paul, and Pacific Railroad bridges (River Miles 22.28 and 22.21) which would not be replaced under this alternative since these seven bridges are unused or are used very little and, according to the Village Engineer, are not necessary for future development of the local areas.

Proceeding in a downstream direction along Lilly Creek, the channelization would lower the existing channel grade by about 6.0 feet at the Chicago and Northwestern Railroad bridge (River Mile 2.59), about 6.0 feet at the W. Mill Road crossing of Lilly Creek (River Mile 1.88), and about 2.0 feet at the W. Good Hope Road crossing of Lilly Creek (River Mile 0.84). Upstream of Jerry Lane extended (River Mile 1.55) to W. Silver Spring Road (River Mile 2.97), the channel would be turf-lined with a bottom width of 20 feet, and side slopes would be one on three. Downstream of Jerry Lane extended to the confluence with the Menomonee River, the bottom and part of the sidewalls would be lined with concrete to prevent erosion and to reduce the channel width in the reach between Oakwood Drive extended (River Mile 1.65) and W. Good Hope Road (River Mile 1.16) where local streets and structures are close to the stream. The concrete bottom would be 12 feet wide and the sidewalls would have three on one slopes with concrete up to the 10-year recurrence interval stage resulting in a total concrete width of approximately 30 feet.

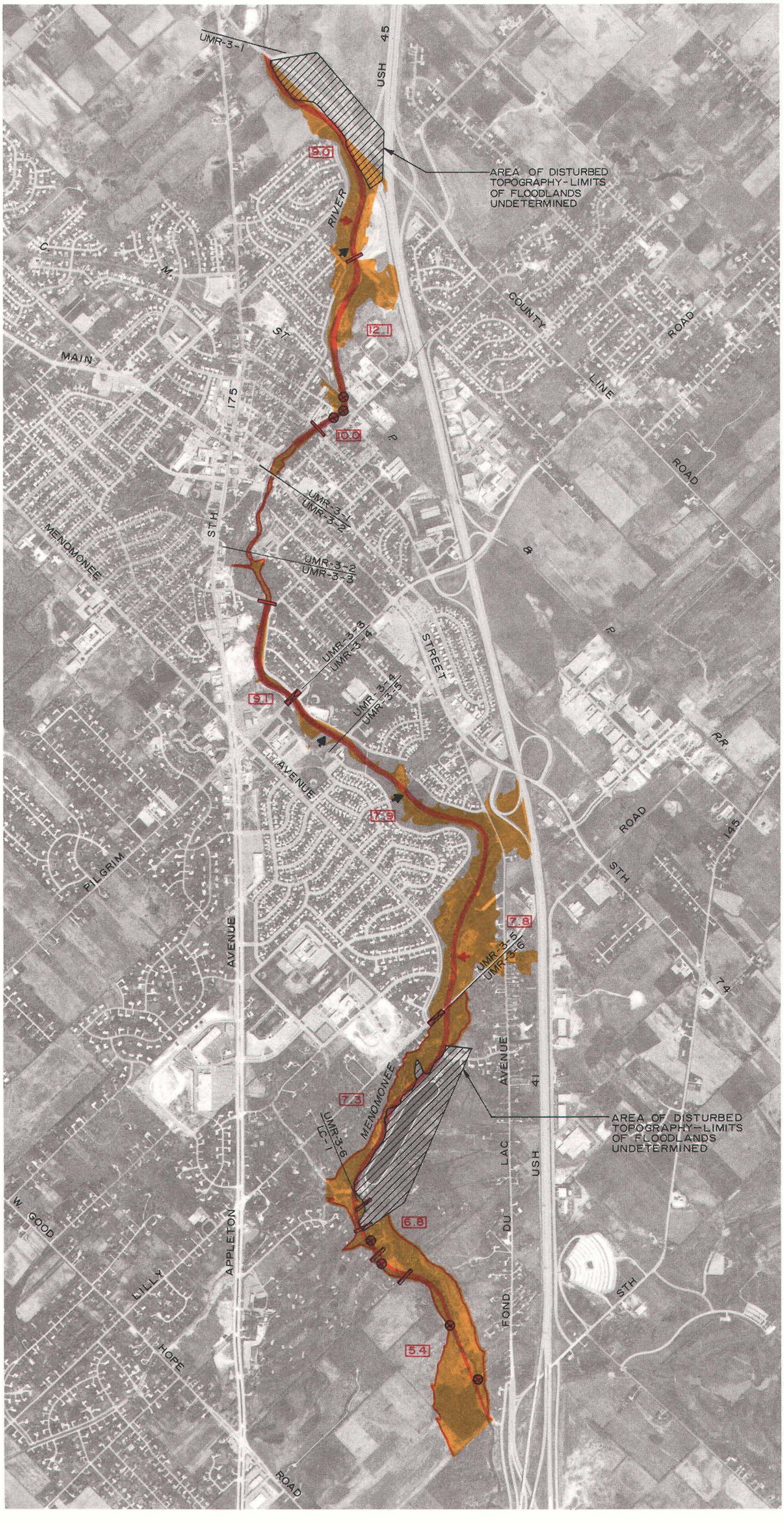
The channelization would require that the following seven crossings of Lilly Creek—listed in downstream order—be replaced with structures which span the improved channel without obstructing the flow in any manner: Chicago and Northwestern Railroad (River Mile 2.59), Bobolink Avenue (River Mile 2.48), Kaul Avenue (River Mile 2.43), W. Mill Road (River Mile 1.88), Lilly Road (River Mile 1.80), Brentwood Drive (River Mile 1.06), and W. Good Hope Road (River Mile 0.84). The demolition and reconstruction costs of all of the above structures were charged against this alternative, with the exception of three structures—W. Mill Road, Lilly Road, and W. Good Hope Road—which are recommended for replacement under the adopted jurisdictional highway system plan for Waukesha County. The proposed channelization also affects four private bridges along Lilly Creek (River Miles 2.55, 2.27, 2.20, and 2.11) which would not be replaced under this alternative since they are unused or used very little and not necessary for future development of the local areas. Although the Kaul Avenue and Bobolink crossings of Lilly Creek are hydraulically inadequate for the existing and anticipated flows, they are structurally sound and could carry future traffic volumes adequately; therefore, to be consistent with previous analyses under the watershed study, the replacement costs for these two structures were included in this channelization alternative.

The average annual cost of the Menomonee River portion of the major channelization project, computed using an interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $136,200 consisting of the following: amortization of the $1,569,600 capital costs of the channel modifications, amortization of the $509,000 capital costs of bridge demolition and reconstruction, and $4,300 in annual operation costs. Assuming that the major channelization would completely eliminate all direct and indirect flood damages along the Menomonee River in the Village of Menomonee Falls, the average annual flood abatement benefit is estimated at about $36,300, yielding a benefit-cost ratio of 0.27 with an annual excess of costs over benefits of $99,900. Therefore, while ultimate major channelization of portions of the Menomonee River as tentatively proposed by the Village of Menomonee Falls is technically practicable, it is not an economically sound means of resolving existing and forecast flood problems along the Menomonee River.

The average annual cost of the Lilly Creek portion of the major channelization project, computed using an interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $158,200

Map 31

CHANNEL MODIFICATIONS ALONG THE MENOMONEE RIVER AND LILLY CREEK IN THE VILLAGE OF MENOMONEE FALLS AS PROPOSED BY MENOMONEE FALLS



LEGEND

- 100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS
- PROPOSED MAJOR CHANNEL--CONCRETE AND TURF LINED
- PROPOSED MAJOR CHANNEL--TURF LINED
- 7.8 APPROXIMATE DEPTH OF PROPOSED CHANNEL IN FEET
- PROPOSED BRIDGE REPLACEMENT
- PROPOSED BRIDGE REPLACEMENT (COST ASSIGNED TO PREVIOUSLY ADOPTED PLAN)
- PROPOSED BRIDGE ABANDONMENT
- EXISTING STORM SEWER OUTFALL REQUIRING LOWER CHANNEL GRADE
- PLANNED STORM SEWER OUTFALL REQUIRING LOWER CHANNEL GRADE
- 100-YEAR RECURRENCE INTERVAL FLOOD HAZARD LINE BELOW LILLY ROAD WITH MAJOR CHANNELIZATION
- UMR-3-5 / UMR-3-6 REACH IDENTIFICATION

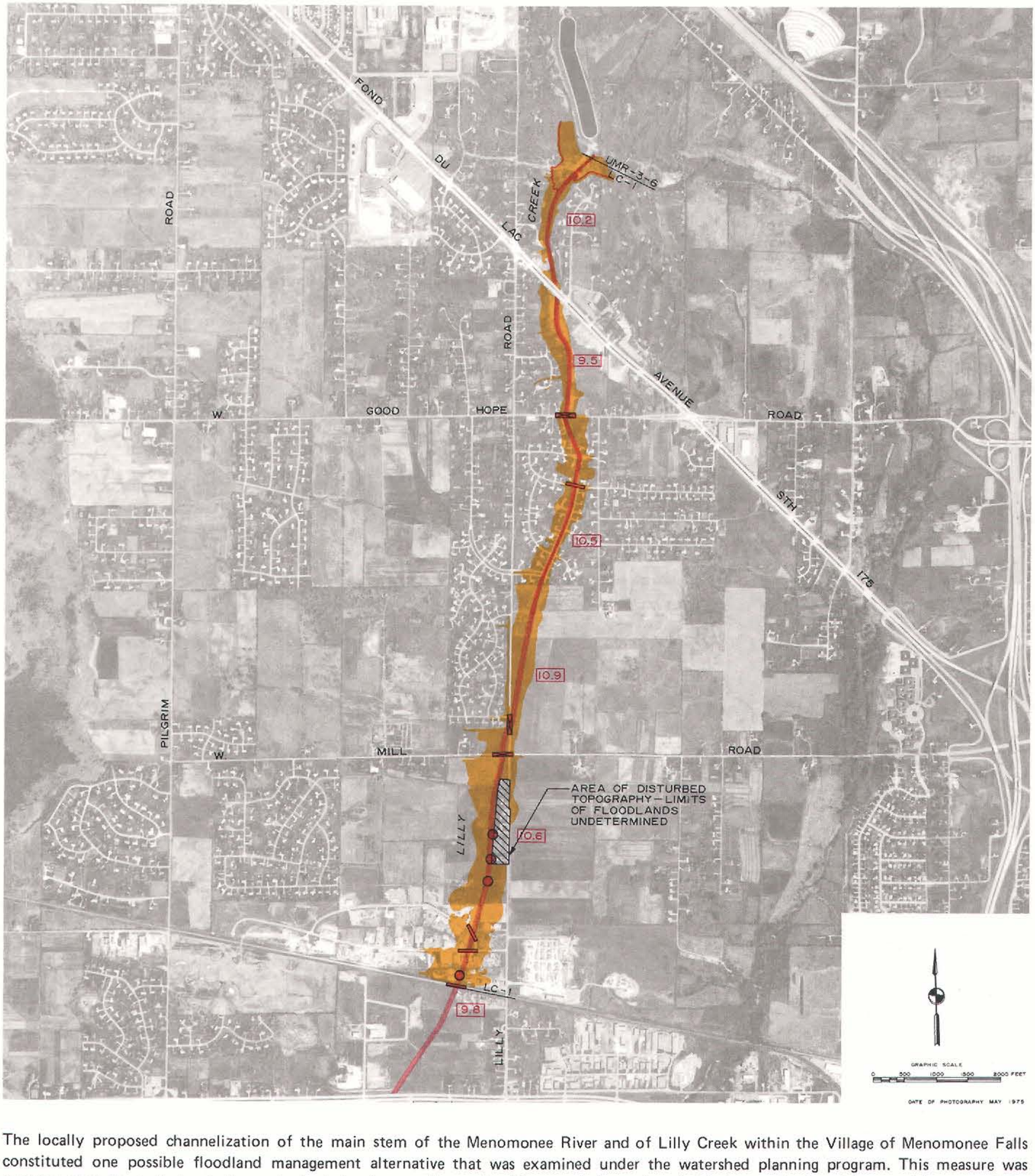
NOTES:

1. EXCEPT FOR REACHES UMR-3-2 AND UMR-3-6 ON THE MENOMONEE RIVER, THE 100-YEAR RECURRENCE INTERVAL FLOOD WOULD BE CONTAINED WITHIN THE PROPOSED CHANNEL
2. THE EXISTING CHANNEL GRADE ALONG LILLY CREEK WOULD NOT PERMIT THE OPERATION OF PLANNED STORM SEWERS

GRAPHIC SCALE
0 500 1000 1500 2000 FEET

DATE OF PHOTOGRAPHY MAY 1975

Map 31—continued



The locally proposed channelization of the main stem of the Menomonee River and of Lilly Creek within the Village of Menomonee Falls constituted one possible floodland management alternative that was examined under the watershed planning program. This measure was recommended for inclusion in the watershed plan because it would mitigate existing and probable future flood problems and because of the Village commitment to channelization as reflected in the location, size, elevation, and grade of existing and proposed storm sewers and storm sewer outfalls.

Source: SEWRPC.

consisting of the following: amortization of the $1,771,500 capital cost of the channel modifications, amortization of the $652,300 capital cost of bridge demolition and reconstruction, and $2,200 in annual operation costs. Assuming that the major channelization would completely eliminate all direct and indirect flood damages along Lilly Creek in the Village of Menomonee Falls, the average annual flood abatement benefit is estimated at about $109,400, yielding a benefit-cost ratio of 0.69, and an annual excess of costs over benefits of $48,800. Therefore, while the ultimate major channelization of Lilly Creek as tentatively proposed by the Village of Menomonee Falls is technically practicable, it is not an economically feasible means of resolving existing and forecast flood problems along Lilly Creek.

Bridge and Culvert Alteration or Replacement for Flood Control Purposes: The removal or alteration of selected bridges or culverts on the Menomonee River and Lilly Creek in the Village of Menomonee Falls was examined as a potential means of reducing the flood problems in the reaches immediately upstream of such crossings. There is only one stream crossing in the four reaches that produces sufficient backwater to affect the flood stages in a flood-prone reach: that is the W. Good Hope Road crossing of Lilly Creek at River Mile 0.84, which exhibits a backwater of about 6.5 feet under year 2000 plan-100-year recurrence interval discharge conditions. While removal or modification of this structure so as to essentially eliminate the backwater effect would reduce local flood stages, monetary flood risks would not be significantly reduced throughout the upstream flood-prone reach primarily because of the steep channel grade in this area; therefore, further technical and economic analyses of alteration or replacement of this bridge were not considered warranted. Inasmuch as the W. Good Hope Road bridge is to be replaced in accordance with the adopted jurisdictional highway system plan for Waukesha County, some flood relief will accrue to the upstream residential area provided that the new crossing is designed in accordance with the standards set forth in Chapter II of this volume.

Concluding Statement: One structural floodland management alternative—major channel modification as proposed by the Village—and one nonstructural measure—structure floodproofing and removal—were examined as possible solutions to the flood problems that exist within three flood-prone reaches along the Menomonee River in the Village of Menomonee Falls. In addition, a third alternative, that of taking no action, is available to public agencies concerned, and the flood damages attendant to this alternative provided an important basis for analysis of the potential benefits associated with each of the alternatives.

The principal features of and the cost and benefits associated with each of the floodland management alternatives examined for the Menomonee River within the Village are summarized in Table 28 together with the major favorable and unfavorable nontechnical and noneconomic considerations likely to influence selection of the most desirable solutions. In addition to alternatives identified in the table, the diversion of floodwaters to Lake Michigan and temporary storage of floodwaters in mined storage chambers beneath the watershed were subjected to a preliminary assessment for possible application in the watershed. Although these two alternatives were determined to be technically feasible, both were shown to be economically unsound by a wide margin. A preliminary assessment also indicated that the use of dikes and floodwalls is an extremely uneconomic means of resolving the flood problem in the three flood-prone reaches along the Menomonee River within the Village and in the flood-prone reach along Lilly Creek.

The only technically practicable and economically feasible means of resolving existing and forecast flood problems along the Menomonee River in the Village of Menomonee Falls is the use of structure floodproofing and removal. Therefore, it was recommended by the Commission staff that structure floodproofing and removal be implemented, recognizing that all floodproofing measures should be applied under the guidance of a qualified engineer. Failure to utilize adequate professional supervision is likely to result in damage to the structure during a major flood event.

Two different structural floodland management alternatives—major channel modification, as proposed by the Village, and bridge alteration—and one nonstructural measure—structure floodproofing and removal—were examined as possible solutions to the flood problem that exists along Lilly Creek in the Village of Menomonee Falls. In addition to a fourth alternative, that of taking no action, is available to the public agencies concerned and the flood damages attendant to that alternative provided an important basis for an analysis of the potential benefits associated with each of the other alternatives.

The principal features of and the cost benefits associated with each of the floodland management alternatives for Lilly Creek are summarized in Table 28 together with the major favorable and unfavorable nontechnical and noneconomic considerations likely to influence selection of the most desirable solution. Structure floodproofing and removal are the only technically practicable and economically feasible means of resolving existing and forecast problems along the entire Lilly Creek flood-prone reach in the Village of Menomonee Falls.

Therefore, it was recommended by the Commission staff that structure floodproofing and removal be the primary means for resolving existing and forecast flood problems along Lilly Creek in the Village of Menomonee Falls subject to the condition that the floodproofing measures be applied under the supervision of a qualified engineer.

Action of the Menomonee River Watershed Committee: A complete revaluation of the locally proposed channelization measures along portions of the Menomonee River and Lilly Creek in the Village of Menomonee Falls must include, in addition to flood damage mitigation, consideration of the relationship between the proposed channel alterations, particularly the associated reduced channel bottom grade, and the grades of existing or locally proposed storm sewer outfalls along both the Menomonee

River and Lilly Creek. According to the Village Engineer, a lower channel grade associated with the locally proposed channelization is needed to achieve the design capacity of the following existing storm sewer outfalls along the main stem of the Menomonee River as shown on Map 31: an outfall near the Rivercourt Shopping Center at River Mile 22.80 and two outfalls near the Pilgrim Road Sewage treatment plant at River Miles 21.00 and 20.72. In addition, a lower channel grade is required to facilitate achieving the design capacity of planned storm sewers that are proposed to discharge to the Menomonee River at the following locations: near the Rivercourt Shopping Center at River Mile 22.74 where a planned storm water outfall will serve primarily residential development, and near the Lilly Road crossing of the Menomonee River at River Mile 19.98 where a planned storm water outfall will serve an industrial-commercial area. A lower channel grade is also needed to facilitate operation of storm sewers serving existing and proposed industrial and residential land lying along both sides of most of the 3.0-mile-long reach of Lilly Creek downstream of W. Silver Spring Drive. These existing and proposed storm sewers discharge to Lilly Creek at approximately two to three block intervals. The planned storm sewer systems are designed to drain land zoned for residential, commercial, and industrial use in conformance with local and regional land use plans. In the opinion of the Village Engineer, these locally proposed channel improvements represent a committed decision in the sense that significant local construction funds have been expended for urban storm sewers and considerable effort has been expended in local storm drainage system planning, all of which are based on the grade of the locally proposed channel along portions of the Menomonee River and Lilly Creek.

In light of the Village commitment to channelization as reflected by the location and size and grades of existing and proposed storm sewers and storm sewer outfalls, the Menomonee River Watershed Committee recommends that the channelization alternative be used to resolve existing and probable future flood problems along the Menomonee River and Lilly Creek within the Village of Menomonee Falls. This approach will resolve existing and probable future flood problems along portions of the Menomonee River and Lilly Creek in a manner that recognizes and complements the existing and locally proposed storm water drainage system. It is recognized that the channel modifications are likely to be constructed in a phased manner in response to local needs and availability of funding.

The City of Wauwatosa

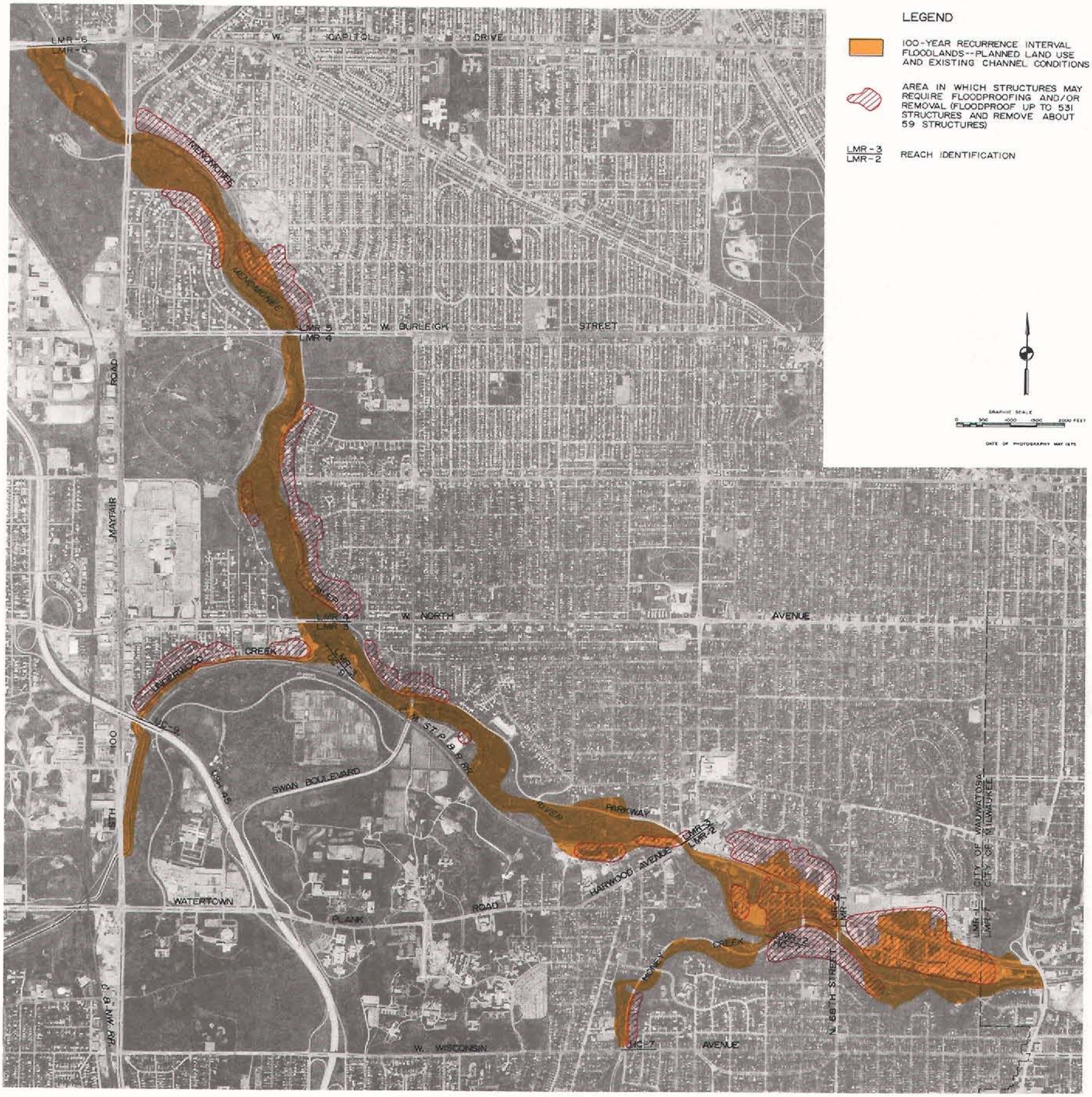
The Flood Problem: As shown on Map 15, the City of Wauwatosa contains eight flood-prone reaches on the Menomonee River watershed stream system. Six of these reaches are located along a 7.14-mile-long portion of the Menomonee River, one along a 0.75-mile-long portion of Underwood Creek, and one along a 0.91-mile-long portion of Honey Creek. For the City as a whole, average annual monetary flood risks attributable to both primary and secondary flooding under existing conditions are estimated at about $229,300, whereas the average annual monetary flood risks under year 2000 land use and floodland development conditions are estimated at about $460,900, a 50 percent increase over existing conditions. It should be emphasized that the increase in average annual monetary damages under year 2000 plan conditions is attributed solely to anticipated changes in land use development in upstream portions of the watershed inasmuch as the analysis presumes that no new flood-prone structures will be constructed in the City of Wauwatosa. As discussed earlier in this chapter, complete development of the floodland and nonfloodland portions of the watershed that are tributary to the Menomonee River, Underwood Creek, and Honey Creek in the City of Wauwatosa could be expected to result in an approximately six-fold increase in average annual monetary risks. If additional flood-prone development were permitted within the City of Wauwatosa, even higher monetary risks would be incurred. As a result of direct and indirect damages associated with flooding of the Menomonee River, Underwood Creek, and Honey Creek, the City may be expected to incur about $2.5 million in flood damages during a 100-year recurrence interval flood under existing conditions, and damages of about $3.5 million under year 2000 plan conditions.

For analytical purposes the flood-prone areas within the City of Wauwatosa were divided into four sections. Section 1 consists of flood-prone areas located along 1.34 miles of the Menomonee River downstream of Harwood Avenue. Section 2 consists of flood-prone areas located along 5.8 miles of the Menomonee River upstream of Harwood Avenue to W. Capitol Drive. Section 3 consists of flood-prone areas located along 0.91 miles of Honey Creek. Section 4 consists of flood-prone areas located along 0.75 miles of Underwood Creek. This sectional approach was employed because the nature and severity of the flood problems in the City of Wauwatosa are highly variable among the various flood-prone reaches and, therefore, the best solutions to the flood problems are likely to vary from one riverine area to another. For example, both primary and secondary flooding occur in Section 1, whereas essentially only secondary flooding occurs in Sections 2, 3, and 4 with very little overland flooding. Furthermore, while average annual flood damages in Section 1 under plan conditions total $247,000 per mile of riverline area, average annual damages in Sections 2, 3, and 4 total, respectively, only $22,000, $800, and $5,200 per mile. Therefore, the flood problem is much more severe in Section 1 than in Sections 2, 3, and 4 and consequently, there may be expected to be a greater number of economically feasible alternative solutions for the problems in Section 1.

Floodproofing and Removal of Structures: A structure floodproofing and removal alternative was developed and analyzed for each section to determine if a structure-by-structure approach would constitute a technically feasible, economically sound, and environmentally acceptable solution to the flood problem in the City. The design criteria and overall approach used in this analysis were identical to that applied in the Village of Elm Grove. The floodproofing and removal alternative is shown on Map 32 and the attendant costs and benefits are set forth in Table 29.

Map 32

STRUCTURE FLOODPROOFING AND REMOVAL ALONG THE MENOMONEE RIVER, UNDERWOOD CREEK, AND HONEY CREEK IN THE CITY OF WAUWATOSA



Structure floodproofing and removal were examined as a possible means of resolving existing and forecast flood problems along the following four stream reaches within the City of Wauwatosa: the Menomonee River between the eastern limits of the City and Harwood Avenue, the Menomonee River reach between Harwood Avenue and W. Capitol Drive, the Honey Creek reach between the Menomonee River and W. Wisconsin Avenue, and the Underwood Creek reach between the Menomonee River and the Zoo Freeway.

Source: SEWRPC.

Table 29

PRINCIPAL FEATURES AND COSTS AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE CITY OF WAUWATOSA

Menomonee River Reach Between the Eastern Limits of the City and Harwood Avenue

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
Number	Name	Description		Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	
1	No Action	–	Yes	–	–	–	–	330.9	0.0	- 330.9	0.00	No	–	–	No
2	Structure Floodproofing and Removal	a. Floodproof up to 200 residential and 51 business, commercial and other b. Remove up to 50 residential structures	Yes	Floodproofing Removal Subtotal	1,400.0 2,000.0 3,400.0	216.8	0.0	216.8	330.9	114.1	1.53	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	No
3	Major Channel Modification	a. 1.84 miles of major channel b. Replace 2 stream crossings	Yes	Channel Bridges Subtotal	4,053.0 578.6 4,631.6	293.8	0.9	294.7	330.9	36.2	1.12	Yes	--	1. Aesthetic impact in residential areas, in Hart Park, and to the parkway partly due to the extensive loss of trees and shrubs	No
4	Dikes and Floodwalls	a. 1.13 miles of dike b. 0.71 miles of floodwall c. Replace 3 stream crossings d. Install 6 stormwater pumping stations	Yes	Dikes Floodwalls Bridges Pumps Subtotal	422.0 819.0 1,320.0 390.0[e] 2,951.0	187.2	7.7	194.9	330.9	136.0	1.70	Yes	--	1. Aesthetic impact of visual barrier 2. Pumping station operation and maintenance is critical to effective functioning of the sytem	No
5	Channelization-Structure Floodproofing and Removal Composite	a. 1.22 miles of major channelization b. Floodproof up to 76 residential and 17 commercial and industrial structures c. Remove up to 61 residential structures d. Replace 1 stream crossing	Yes	Channel Floodproofing Removal Bridges Subtotal	2,940.2 100.2 2,603.0 356.0 5,999.4	380.6	0.6	381.2	330.9	- 50.3	0.87	No	1. Floodproofing component provides immediate partial flood relief at discretion of property owners 2. With floodproofing, most of the costs could be borne by beneficiaries 3. Consistent with long range plan to rejuvenate "Old Village Center" 4. Permit needed expansion of Hart Park 5. Long-range solution to decreasing property values	1. Aesthetic impact in residential areas and to the parkway partly due to the extensive loss of trees and shrubs 2. Complete, voluntary implementation of floodproofing component unlikely and therefore, left with a significant residual flood problem 3. Overland flooding and some attendant problems remain with floodproofing 4. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur 5. Likely opposition to extensive removal of residential structures	Yes

Menomonee River Reach Between Harwood Avenue and Capitol Drive

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
Number	Name	Description		Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	
1	No Action	--	Yes	–	–	–	--	125.4	0.0	- 125.4	0.00	No	–	–	No
2	Structure Floodproofing and Removal	a. Floodproof up to 203 residential and 8 other structures b. Remove up to 9 residential structures	Yes	Floodproofing Removal Subtotal	310.8 631.9 942.7	59.9	0.0	59.9	125.4	65.5	2.09	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	Yes
3	Bridge Alteration or Replacement	Alter or replace 4 bridges causing backwater in excess of one foot	No	–	--	--	--	--	--	--	--	--	–	–	No

Honey Creek Reach Between the Menomonee River and Wisconsin Avenue

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
Number	Name	Description		Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	
1	No Action	--	Yes	–	--	--	--	0.7	0.0	- 0.7	0.00	No	–	–	No
2	Structure Floodproofing	Floodproof up to 13 residential structures	Yes	Floodproofing	3.3	0.2	0.0	0.2	0.7	0.5	3.50	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	Yes
3	Bridge Alteration or Replacement	Alter or replace 3 bridges causing backwater in excess of one foot	No	–	--	--	--	--	--	--	--	No	--	--	No

Underwood Creek Reach Between the Menomonee River and the Zoo Freeway

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
Number	Name	Description		Capital Cost Item	Capital Cost (In 1,000 Dollars)	Annual Amortization of Capital Cost (In 1,000 Dollars)	Annual Operation and Maintenance Cost (In 1,000 Dollars)	Total Annual Cost (In 1,000 Dollars)	Annual Benefit (In 1,000 Dollars)	Annual Benefit Minus Annual Cost (In 1,000 Dollars)	Benefit-Cost Ratio	Economically Feasible?	Positive	Negative	
1	No Action	--	Yes	--	--	–	--	3.9	0.0	- 3.9	0.00	No	--	--	No
2	Structure Floodproofing	Floodproof up to 56 residential structures	Yes	Floodproofing	29.8	1.9	0.0	1.9	3.9	2.0	2.05	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professional advice and, as a result, structure damage may occur	Yes

[a] *Economic analyses are based on an annual interest rate of 6 percent and assume a 50 year amortization period and project life.*

[b] *A preliminary technical and economic assessment of diversion of floodwaters from the lower portion of the watershed to Lake Michigan and temporary storage in mined chambers beneath the watershed indicated that while these would be technically feasible they would be extremely uneconomic means of resolving flood problems in all or portions of the watershed. A preliminary technical assessment of a system of 11 detention reservoirs revealed that such a system would not be a technically practical method for resolving flood problems within the City of Wauwatosa. Minor channelization was judged to be technically impractical based on the results of an analysis of Underwood Creek in the Village of Elm Grove.*

[c] *Economic analyses were not done for technically impractical alternatives.*

[d] *Presented only for technically and economically feasible alternatives with exception of the composite channelization-structure floodproofing and removal alternative.*

[e] *Present worth cost based on a 25 year economic life.*

Source: SEWRPC.

For Section 1 located along the Menomonee River, the analyses indicated that about 50 structures would have to be removed from the 100-year recurrence interval floodlands under this alternative, and a total of about 251 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damages to private residences and commercial structures within this Section would be virtually eliminated by structure floodproofing and removal. Table 29 sets forth a schedule of the approximate number and types of structures to be floodproofed and removed and also summarizes the estimated costs and benefits. Assuming that the aforementioned structure floodproofing and removal measures would be fully implemented in Section 1 and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the equivalent average annual cost is estimated at about $216,800, consisting entirely of the amortization of the $3.4 million capital costs of the structure floodproofing and removal—$1.4 million for floodproofing and $2.0 million for removal. The average annual flood abatement benefits are estimated at about $330,900, yielding a benefit-cost ratio of 1.53 and an excess of annual benefits over annual costs of about $114,100. Therefore, the structure floodproofing and removal alternative would be both technically and economically feasible in Section 1.

For Section 2, also located along the Menomonee River, the analyses indicated that about 9 structures would have to be removed from the 100-year recurrence interval flood lands, and a total of about 211 structures located in the primary and secondary flooding zones may be required some form of floodproofing. Future flood damages to private residences and commercial structures within Section 2 would be virtually eliminated by the structure floodproofing and removal. Table 29 sets forth a schedule of the approximate number and types of structures to be floodproofed and removed and also summarizes the estimate costs and benefits. Assuming that the aforementioned structure floodproofing and removal measures would be fully implemented and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the equivalent of average annual costs is estimated at about $59,900, consisting entirely of the amortization of the $942,700 capital costs of the structure floodproofing and removal—$19,700 for floodproofing and $40,200 for removal. The average annual flood abatement benefits is estimated at about $125,400, yielding a benefit-cost ratio of 2.09 and an excess of annual benefits over cost of about $65,500. Therefore the structure floodproofing and removal alternative would be both technically, and economically feasible in Section 2.

For Section 3 located along Honey Creek, the analyses indicated that no structures would have to be removed from the 100-year recurrence interval floodlands and that a total of only about 13 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damages to private residences and commercial structures within Section 3 would be virtually eliminated by the structure floodproofing. Table 29 sets forth a schedule of the approximate number and types of structures to be floodproofed and also summarizes the estimate costs and benefits. Assuming that the structure floodproofing measures would be fully implemented, and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the equivalent of average annual costs is estimated at about $200, consisting entirely of the amortization of the $3,300 capital costs of the structure floodproofing. The average annual flood abatement benefits is estimated at about $700, yielding a benefit cost ratio of 3.50, and an excess of annual benefits over costs of about $500. Therefore, the structure floodproofing alternative would be both technically and economically feasible in Section 3.

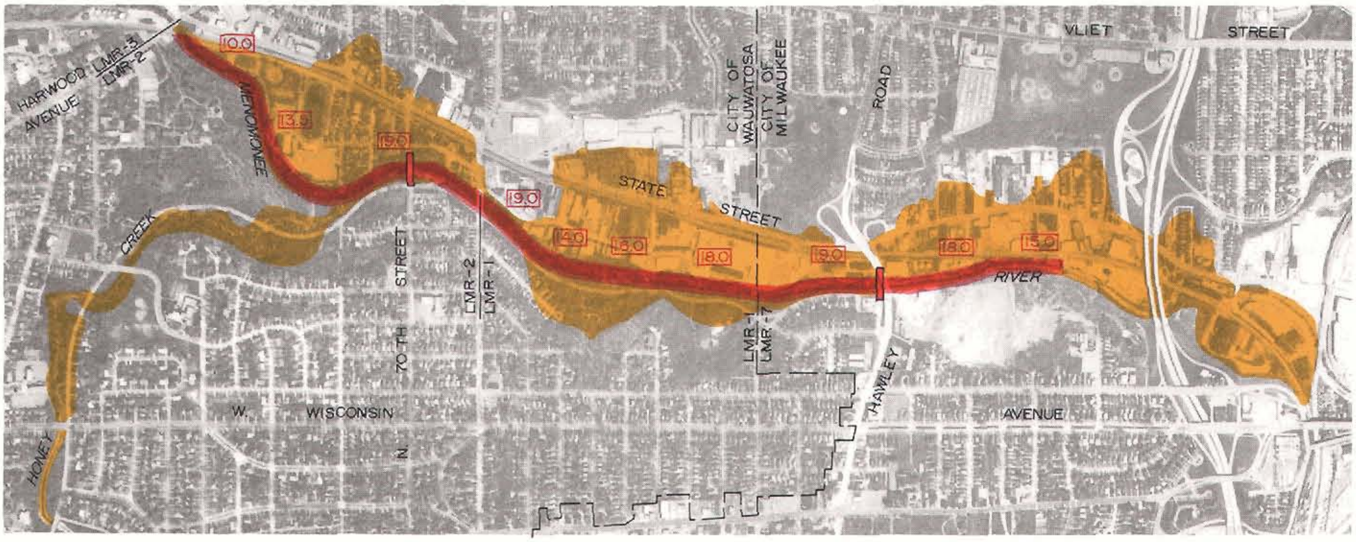
For Section 4, located along Underwood Creek, the analyses indicated that no structures would have to be removed from the 100-year recurrence interval floodlands, and a total of about 56 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damages to private residences and commercial structures within Section 4 would be virtually eliminated by the structure floodproofing and removal. Table 29 sets forth a schedule of the approximate number and types of structures to be floodproofed and removed and also summarizes the estimate costs and benefits. Assuming that the aforementioned structure floodproofing and removal measures would be fully implemented, and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the equivalent of average annual costs is estimated at about $1,900, consisting entirely of the amortization of the $29,800 capital costs of the structure floodproofing. The average annual flood abatement benefit is estimated at about $3,900, yielding a benefit-cost ratio of 2.05 and an excess of annual benefits over cost of about $2,000. Therefore the structure floodproofing and removal alternative would be both technically and economically feasible in Section 4. While the Milwaukee-Metropolitan Sewerage Commissions' trunk sewer construction program currently underway in Wauwatosa will reduce some sewer backup problems along Underwood Creek and the Menomonee River during the small, more frequent floods, it is not expected to substantially reduce the secondary flooding problems during major flood events.

Channel Modifications: A major channel modification alternative was developed for Section 1. Major channel modification alternatives were not developed for Sections 2, 3, and 4 because the monetary flood damage risks in this area, which are mainly attributable to secondary flooding, are not sufficient to warrant consideration of a major flood control project. Furthermore, Section 3, located along the lower reaches of Honey Creek, and Section 4, located along the lower reaches of Underwood Creek, have already been provided with some channel improvements.

The channel proposed for construction along that portion of the Menomonee River within the City of Wauwatosa downstream of Harwood Avenue was designed to pass the 100-year recurrence interval flood discharges under year 2000 land use plan conditions without overtopping. The major channelization alternative is shown on Map 33. The

Map 33

MAJOR CHANNEL MODIFICATIONS ALONG THE MENOMONEE RIVER IN THE CITY OF WAUWATOSA



LEGEND

100-YEAR RECURRENCE INTERVAL FLOODLANDS--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

PROPOSED MAJOR CHANNEL--CONCRETE AND TURF LINED

19.0 APPROXIMATE DEPTH OF PROPOSED CHANNEL IN FEET

PROPOSED BRIDGE REPLACEMENT

LMR-2 / LMR-1 REACH IDENTIFICATION

NOTE: THE 100-YEAR RECURRENCE INTERVAL FLOOD WOULD BE CONTAINED WITHIN THE PROPOSED CHANNEL

GRAPHIC SCALE
0 500 1000 1500 2000 FEET

DATE OF PHOTOGRAPHY MAY 1975

Because of the severity of the historic and forecast flood problem along the Menomonee River in the City of Wauwatosa between Harwood Avenue and the Wauwatosa-Milwaukee boundary, a variety of floodland management measures was examined. One such measure consists of major channelization of the Menomonee River beginning at Harwood Avenue in the Old Village area of Wauwatosa and extending downstream approximately 0.50 mile into the City of Milwaukee. This alternative was shown to be a technically practicable and economically feasible solution to the flood problem, but would have a negative aesthetic impact on the appearance of riverine area parklands and adjacent residential areas throughout the entire affected reach.

Source: SEWRPC.

salient physical characteristics of the major channel modification and the attendant costs and benefits are set forth in Table 29. Under this alternative, major channel improvements would be carried out over a total reach of 1.84 miles. The improved channel would be located along the alignment of the Menomonee River and would extend in a downstream direction from the Harwood Avenue bridge at River Mile 6.72 in the "Old Village" area of Wauwatosa, cross the City of Wauwatosa-City of Milwaukee line at River Mile 5.38, and terminate in Milwaukee at about River Mile 4.88, or about 0.25 miles downstream of Hawley Road.

The channel bottom profile and the channel cross-sectional shape at both the upstream and downstream ends of the channelized reach would be designed so as to effect an acceptable transition to the existing channel grade and shape. The extension of the channel from the City of Wauwatosa into the City of Milwaukee is necessary in order to substantially reduce Menomonee River flood stages near the eastern limits of Wauwatosa and to achieve an acceptable downstream transition with the existing channel. Proceeding in a downstream direction, the channelization would lower the existing Menomonee River channel grade by about five feet at the confluence of the Menomonee River and Honey Creek (River Mile 6.23), about five feet at N. 68th Street (River Mile 5.96), about three feet at the City of Wauwatosa-City of Milwaukee boundary (River Mile 5.38), and about two feet at Hawley Road (River Mile 5.15). The width of the invert or bottom of the concrete channel within the City of Wauwatosa would be about 40 feet and side slopes would be one on three. The bottom, and the side walls up to the 10-year recurrence interval flood stage, would be lined with concrete resulting in a total concrete width of approximately 90 feet. The channelization would require the replacement of the N. 70th Street bridge and the low bridge at Hawley Road. Although the channel works would pass through the N. 68th Street bridge, it was assumed that this structure could be retained since it was recently rebuilt with a low foundation and an enlarged waterway opening.

Portions of the channel in the vicinity of Hawley Road would be constructed in bedrock which might effect a savings in the cost of construction materials. Much of the monetary savings in construction materials, however, is likely to be offset by increased excavation cost and, therefore, the channelization cost estimates in this reach do not explicitly account for the construction of channel on bedrock.

Assuming that the aforementioned major channelization project would be fully implemented and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at about $294,700, consisting of the following: amortization of the $4,053,000 capital costs of the channel modifications, amortization of the $578,600 capital cost of bridge demolition and reconstruction, and $900 in annual operation and maintenance costs. Assuming that the major channelization would completely eliminate all direct and indirect flood damages along the Menomonee River downstream of Harwood Avenue in the City of Wauwatosa, the average annual flood abatement benefit is estimated at about $330,900, yielding a benefit-cost ratio of 1.12, and an annual excess of benefits over costs of $36,200. Therefore, major channelization may be considered both technically practicable and economically feasible for that reach of the Menomonee River downstream of Harwood Avenue in the City of Wauwatosa.

The major channelization proposal would have a potentially negative aesthetic impact on most of the 1.8-mile-long reach that would be affected inasmuch as most of one or both sides of the reach are utilized for outdoor recreation and related open space use or for residential use. The attractiveness of the existing natural channel and floodplain would be compromised by the extensive cross-section enlargement required for the channelization project and by the placement of the concrete invert and sidewalls. Trees and shrubs lining both sides of the existing channel would have to be removed in order to construct the channel works. The resulting aesthetic impact would be most severe for the reach downstream of N. 70th Street in that this reach contains a thick, but narrow, band of trees and shrubs, most of which would be removed. The aesthetic impact would be apparent to residents of the adjacent areas as well as to users of Hart Park and the Honey Creek Parkway and Parkway Drive and Jacobus Park.

Dikes and Floodwalls: A dike and floodwall alternative was developed for Section 1. Dike and floodwall alternatives were not developed for Sections 2, 3, and 4 because the monetary flood damage risks in this area, which are mainly attributable to secondary flooding, are not sufficient to warrant consideration of a major flood control project. Perhaps even more fundamentally, dikes and floodwalls are not a technically feasible way to resolve secondary flood problems.

The dikes and floodwalls were designed to pass the 100-year recurrence interval flood discharge under year 2000 land use plan conditions through Section 1 with a two-foot freeboard. The dike and floodwall alternative for the Menomonee River downstream of Harwood Avenue in the City of Wauwatosa is shown on Map 34. The salient physical characteristics of the dikes and floodwalls and the attendant costs and benefits are set forth in Table 29. Under this alternative a total of 1.84 miles of earthen dikes and concrete or sheet steel floodwalls similar to those shown on Figure 4 would be constructed along most of both sides of the 1.34-mile-long reach of the Menomonee River downstream of Harwood Avenue. About 1.13 miles of earthen dike and about 0.71 miles of concrete or sheet steel floodwall would be required. Extensive use of the more costly concrete, or sheet steel floodwalls rather than earthen dikes, would be necessary at certain locations along both sides of the river due to the limitations imposed by the very narrow band of open land available between the Menomonee River and the Honey Creek Parkway Drive which lies immediately south of and parallel to the River. In order to convey the design floodflow with the minimum freeboard of two feet, the earthen dikes and concrete floodwalls would be extremely high in some locations with a maximum height above the existing ground level of about 10 feet along the north side of the Menomonee River at Hart Park in Wauwatosa.

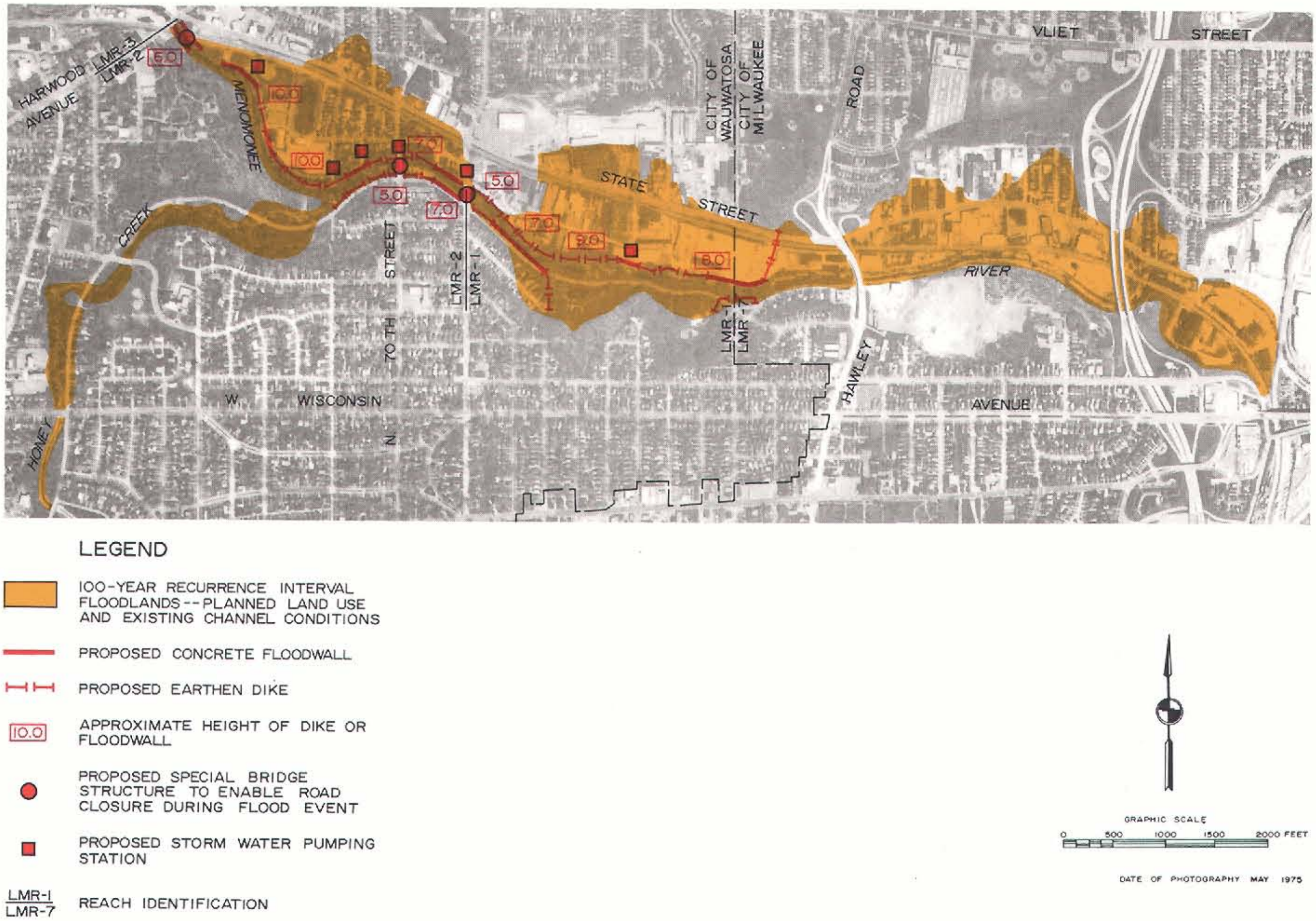
The dike and floodwall alternative would require the construction of new bridges at three crossings of the Menomonee River in order to contain the flood waters within the confines of the dikes and floodwalls. These new structures would be required at the following crossings—listed in downstream order—of the Menomonee River; the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge, the N. 70th Street bridge, and the N. 68th Street bridge.

In addition, the dike and floodwall alternative would have to include provision for construction of a minimum of six major storm water lift or pumping stations and the installation of backwater gates at or near the ends of the storm sewer outfalls or other drainageways that are tributary to the Menomonee River. These facilities would be required to prevent the movement of floodwaters from the River to the surrounding urban area via these storm sewers and drainageways and to prevent the accumulation of lateral runoff behind the dikes and floodwalls, thereby creating local drainage problems.

Assuming that the dikes and floodwalls alternative would be fully implemented in Section 1 and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at $194,900, consisting of: amortization of the $1,241,000 capital costs of the dikes and floodwalls and the land necessary to construct them, amortization of the $1,320,000 capital cost of the new river crossings, amortization of the $390,000 capital costs of the backwater

Map 34

DIKE-FLOODWALL SYSTEM ALONG THE MENOMONEE RIVER IN THE CITY OF WAUWATOSA



Dikes and floodwalls, supplemented with storm water pumping stations, constitute another alternative measure considered for resolution of existing and forecast flood problems along the Menomonee River in the City of Wauwatosa downstream of W. Harwood Avenue. While these measures were shown to be technically and economically feasible, it is likely that the aesthetic impact of dikes and floodwalls, having a height up to 10 feet above existing floodplain ground grades, would render this alternative publicly unacceptable.

Source: SEWRPC.

control and pumping facilities, and $7,700 in annual operation and maintenance costs. Assuming that the dike-floodwall system would completely eliminate all direct and indirect flood damages along the Menomonee River downstream of Harwood Avenue, the average annual flood abatement benefit is estimated at about $330,900 yielding a benefit-cost ratio of 1.70 and an annual excess of benefits over costs of about $136,000. Therefore, the dike and floodwall alternative would be both technically and economically feasible in Section 1.

The height of the dikes and floodwalls may be considered extremely unsightly by owners or tenants of homes in the residential area located in this section north of the Menomonee River between N. 70th Street and N. 72nd Street and south of the River between N. 66th Street extended and N. 70th Street. The crest of the dikes and floodwalls along the River in this area would be about five to seven feet above the existing ground grade. These structures would dominate the local environment in addition to forming a visual barrier between local residents and the Menomonee River. Users of the Honey Creek Parkway Drive, which parallels the River on the south, would have their view of the River completely obstructed over a six-block length of the drive from N. 66th Street extended to N. 72nd Street by a dike-floodwall structure that would be up to seven feet high. The view of the Menomonee River from Hart Park also would be blocked by the approximately 10-foot-high dike and floodwall which would have to be constructed along the north bank of the River in that area. A five- to nine-foot-high dike-floodwall structure would have to be placed along the north side of the Menomonee

River from N. 60th Street to N. 70th Street to protect the commercial development located on the north floodplain of the Menomonee River in that area. The visual impact of this structure on parkway users could be reduced by constructing the dikes and floodwalls as far away from the north bank of the River as possible so as to permit retention of most of the trees and shrubs lining the north bank of the Menomonee River.

Another negative aspect of the dike and floodwall system is its dependence on the successful operation of backwater gates and pumping facilities at a minimum of six storm water outfalls. In order to assure prompt and proper operation of these facilities, automatic controls would have to be provided and a regular maintenance and testing program instituted.

Bridge or Culvert Alteration or Replacement for Flood Control Purposes: The removal or alteration of selected bridges or culverts on the Menomonee River, Underwood Creek, and Honey Creek in the City of Wauwatosa was examined as a potential means of significantly reducing the flood problems in the reaches immediately upstream of such crossings. All bridges and culverts in these reaches producing backwater in excess of 1.0 feet under year 2000 plan 100-year recurrence interval flood discharge conditions were identified. Four such bridges exist along flood-prone reaches of the Menomonee River upstream of Harwood Avenue. The combination of the Harwood Avenue bridge at River Mile 6.72 and the adjacent Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge produces a backwater effect of about 4.0 feet; however, the River is so deeply incised in this area relative to surrounding topography and structures that there are no flood problems immediately upstream of the bridges. Therefore, this backwater effect is of no practical concern. Farther upstream along the Menomonee River, the W. North Avenue bridge at River Mile 8.50 produces a backwater effect of about 1.0 feet, the W. Burleigh Street bridge at River Mile 9.68 produces a backwater effect of about 1.5 feet, and the W. Capitol Drive bridge at River Mile 11.2 produces a backwater effect of about 2.0 feet. While removal or modification of these structures so as to essentially eliminate the backwater effects would reduce local flood stages, monetary flood risks would not be significantly reduced within the flood-prone reaches and, therefore, further technical and economic analyses of alteration or replacement of these Menomonee River crossings were not considered warranted.

Four bridges located along the flood-prone reach of Honey Creek downstream of the W. Wisconsin Avenue bridge at River Mile 0.91 exhibit backwater effects in excess of 1.0 feet. The Honey Creek Parkway Drive bridge at River Mile 0.17 has a backwater effect of about 1.7 feet, the Portland Avenue bridge at River Mile 0.4 produces a backwater effect of almost 5 feet, the Honey Creek Parkway crossing at River Mile 0.61 produces a backwater effect of about 3 feet, and the W. Wisconsin Avenue bridge at River Mile 0.91 produces a backwater effect of about 3 feet. The upstream three bridges are located within or immediately downstream of the reach along Honey Creek in which secondary flooding occurs and, therefore, alteration or replacement of the three bridges may be a technically practical means of reducing flood problems. Average annual flood damages computed for this reach are very low, however—less than $1,000 per year— so that the alteration or replacement of existing bridges would not be economically feasible. Therefore, further consideration of bridge alteration or replacement along Honey Creek was not considered warranted.

Concluding Statement: Two distinctly different structural floodland management alternatives—major channel modifications and dikes and floodwalls—and one nonstructural measure—a combination of structure floodproofing and structure removal—were examined as possible solutions to the serious flood problems that exist in the City of Wauwatosa along the Menomonee River downstream of Harwood Avenue. In addition, a fourth alternative, that of taking no action, is available to the public agencies concerned, and the flood damages attendant to this alternative provided an important basis for the analyses of the potential benefits associated with each of the other alternatives.

Only two alternatives—structure floodproofing and removal and that of taking no action—were examined as possible solutions to the secondary flood problem that exists along Underwood Creek downstream of the Zoo Freeway in the City. Three alternatives—structure floodproofing and removal, bridge alteration or replacement, and taking no action—were considered as possible solutions to the secondary flood problem that exists along the Menomonee River upstream of Harwood Avenue and along Honey Creek downstream of W. Wisconsin Avenue within the City of Wauwatosa.

The principal features of, and the costs and benefits associated with, each of the floodland management alternatives for each of the above four stream reaches are summarized in Table 29 together with the major favorable and unfavorable nontechnical and noneconomic considerations likely to influence selection of the most desirable solution. In addition to the alternatives identified in the table, the diversion of floodwaters to Lake Michigan and the temporary storage of floodwaters in mined storage chambers beneath the watershed were subjected to a preliminary assessment. Although these two alternatives were determined to be technically feasible, both were shown to be economically unsound by a wide margin.

All of the three structural and nonstructural alternatives initially examined for the Menomonee River reach downstream of Harwood Avenue were found to be technically and economically feasible. Even though structure floodproofing and removal constitutes a technically and economically feasible floodland management alternative for the Menomonee River reach downstream of Harwood Avenue in the City of Wauwatosa, this alternative was eliminated from further consideration for four reasons: First, complete implementation of a voluntary structure floodproofing and removal program is unlikely and, with partial implementation, the City of Wauwatosa would be left with a significant residual problem whenever a major flood event occurs. In spite of the fact that numerous individual property owners may have implemented floodproofing and have incurred the necessary costs, community officials may still be faced with the problem of public demands for action to reduce the flood threat to those structures that have not been voluntarily floodproofed. Second, other viable alternatives are available, each of which could be applied with a significantly higher likelihood of success in eliminating most of the Menomonee River flood problems between Harwood Avenue and the eastern limits of Wauwatosa. Third, even if a voluntary structure floodproofing program were completely carried out, the area would still be subjected to extensive overland flooding that would hamper routine access to and from some riverine area structures, would continue periodically to close local streets to automobile traffic, and, would interfere with the rapid movement of emergency vehicles. Furthermore, yard and street damages and cleanup costs would remain with the structure floodproofing and removal alternative. Fourth, some floodproofing is very likely to be applied without adequate professional advice and, as a result, structure damage is likely to occur and once again City officials are likely to be asked to assist in the resolution of the problem.

Each of the two remaining technically and economically feasible alternatives available for application to the Menomonee River in Wauwatosa downstream of Harwood Avenue—major channel modification and a dike-floodwall system—will detract significantly from the aesthetic values of the River. The visual impact of the dike-floodwall system will be greater than that of channelization since the former will obstruct the view of the River from adjacent residential areas, from Hart Park and from much of the Menomonee River Parkway Drive, while the latter, although drastically altering the channel area, will not obstruct the view of the riverine and surrounding areas. Another significant negative feature unique to the dike-floodwall alternative is the critical reliance on successful operation of necessary backwater gates, pumping facilities, and automatic controls at about six storm water outfalls. This is in marked contrast to the much simpler gravity operation of the major channelization alternative.

After due consideration of the various technical and economic features and other aspects of the channelization alternative and the dike-floodwall alternative, the Commission staff recommended that channelization be employed to resolve existing and forecast flood problems in the City of Wauwatosa along the Menomonee River downstream of Harwood Avenue. Even though channelization does not exhibit cost-benefit characteristics as favorable as those associated with the dike-floodwall alternative, channelization is preferred over the dike-floodwall system because channelization will have less of a negative aesthetic impact and its effective functioning is entirely dependent on gravity flow.

The only economically feasible means of reducing the secondary flooding problem that exists in Wauwatosa along the Menomonee River upstream of Harwood Avenue, along Honey Creek downstream of Wisconsin Avenue, and along Underwood Creek downstream of the Zoo Freeway is structure floodproofing. Although this approach has significant negative features, as identified in Table 29 and as discussed above, it is the only means available for achieving relief from secondary flooding and is recommended for these three reaches. More specifically, it is recommended that floodproofing be applied to those residential structures in the primary and secondary flooding zones along the Menomonee River upstream of Harwood Avenue, along Honey Creek downstream of Wisconsin Avenue, and along Underwood Creek downstream of the Zoo Freeway as identified on Map 32 that are not subject to first flood inundation by the 100-year recurrence interval flood under year 2000 plan conditions. These residential structures should be floodproofed to an elevation two feet above the 100-year recurrence interval flood stage under conditions of the year 2000 land use plan. A total of only nine residential structures were identified for possible removal by virtue of having the first floor at or below the 100-year flood stage. Inasmuch as the estimated differences between the design flood stage and the first floor elevations are small, it is likely that the affected structures could be floodproofed in lieu of removing them.

It is also recommended that commercial and industrial structures subject to primary or secondary flooding be floodproofed, even if the 100-year flood stage is above the first floor, provided that the buildings have sufficient structural strength to withstand the additional forces that they would receive during the design flood event. It is imperative that all floodproofing measures, irrespective of the structure types involved, be applied under the guidance of a registered engineer. Failure to utilize adequate professional supervision is likely to result in damage to the structure during a major flood as well as pose a threat to the owners, tenants, and users of the structure.

Action of the Menomonee River Watershed Committee: After careful consideration of the three technically and economically feasible floodland management alternatives developed by the Commission staff for the Menomonee River in the City of Wauwatosa downstream of Harwood Avenue and after similar consideration of the Commission staff recommendation that channelization be employed to resolve existing and forecast flood problems in that reach, the Menomonee River Watershed Committee requested that the staff develop an additional alternative for the reach. This alternative consists of three components: major channelization along the Menomonee River from a point about 0.25 miles downstream of Hawley Road to an upstream terminus in the form of a drop structure immediately east of the N. 70th Street bridge; acquisition and removal of residential structures in the approximately 13 acre area bounded by the City of Wauwatosa Hart Park on the west, N. 70th Street on the east, W. State Street on the north, and the Menomonee River on the south; and supplemental selected structure floodproofing and removal in other flood-prone areas upstream of N. 70th Street as needed. This channelization-structure floodproofing and removal alternative would reduce the undesirable aesthetic impact of the staff recommended channelization alternative by confining channel modifications to that portion of the stream downstream of N. 70th Street. These aesthetic considerations were deemed particularly important in this reach because of proposals being considered by the City for the renewal of the "Old Village Center" and its immediate environs. Furthermore, it would provide for the ultimate expansion of the City of Wauwatosa Hart Park in an easterly direction along the Menomonee River.

The composite channelization-structure floodproofing and removal alternative is shown in graphic summary form on Map 35 and the salient physical characteristics and attendant costs and benefits are set forth in Table 29. The 1.22-mile-long channelization component of this composite alternative would be located along the existing alignment of the Menomonee River and would extend in a downstream direction from the N. 70th Street bridge at River Mile 6.10 across the City of Wauwatosa-City of Milwaukee line at River Mile 5.38 and terminate in the City of Milwaukee at about River Mile 4.88, or about 0.25 miles downstream of Hawley Road. An approximately 4.5 foot drop in the channel bottom would be provided immediately downstream of the N. 70th Street bridge and the alignment, grade, and cross-section of the channel downstream of that location would be identical to those of the major channel modification alternative described above. The channelization would require a replacement of the low bridge at Hawley Road. Although the channel works would pass under the N. 68th Street bridge, it was assumed that this structure could be retained since it was recently rebuilt with a low foundation and an enlarged waterway opening.

About 49 primarily residential structures would have to be removed from the 100-year recurrence interval floodlands in the approximately 13 acre area bounded by Hart Park on the west, N. 70th Street on the east, W. State Street on the north, and the Menomonee River on the south. In addition, about 12 primarily residential structures may have to be removed from the 100-year recurrence interval floodland in the area north of W. State Street, and a total of about 93 structures located in the primary and secondary flooding zones upstream of N. 70th Street may require some form of floodproofing.

The average annual cost of the composite channelization-structure floodproofing and removal alternative computed, using an annual interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $381,200. This cost consists of: $186,500 for amortization of the $2,940,200 capital costs of the channel modifications, $22,600 for amortization of the $356,000 capital cost of the bridge demolition and reconstruction, $165,200 for amortization of the $2,603,000 capital cost of structure removal, $6,300 for amortization of the $100,200 capital cost of structure floodproofing, and $600 for annual operation and maintenance cost attendant to the channel works. Assuming that the combination of channelization and structure floodproofing and removal would be so implemented as to completely eliminate direct and indirect damages along the Menomonee River downstream of Harwood Avenue in the City of Wauwatosa, the average annual flood abatement benefit is estimated at about $330,900, yielding a benefit-cost ratio of 0.87 and an annual excess of costs over benefits over $50,300. Therefore, while the composite channelization-structure floodproofing removal alternative may be considered technically practicable, it is uneconomic for that reach of the Menomonee River downstream of Harwood Avenue in the City of Wauwatosa.

The benefit-cost analyses indicate that the channelization component of the channelization-structure floodproofing and removal alternative is economic in that the equivalent average annual cost is $209,700 and the equivalent average annual benefit is $259,200, yielding a benefit-cost ratio of 1.24. In contrast, the structure floodproofing and removal component—which would be applied upstream of the N. 70th Street crossing—is markedly uneconomic in that the equivalent average annual cost is $171,500 and the equivalent average annual benefit is $71,700, yielding a benefit-cost ratio of 0.42. The channelization alternative recommended by the Commission staff is also uneconomic for the N. 70th Street-Harwood Avenue reach but not by as wide a margin as the channelization-structure floodproofing and removal alternative. The equivalent average annual cost of channelization in this reach is $85,000 and the equivalent average annual benefit is $71,700 yielding a benefit-cost ratio of 0.84.

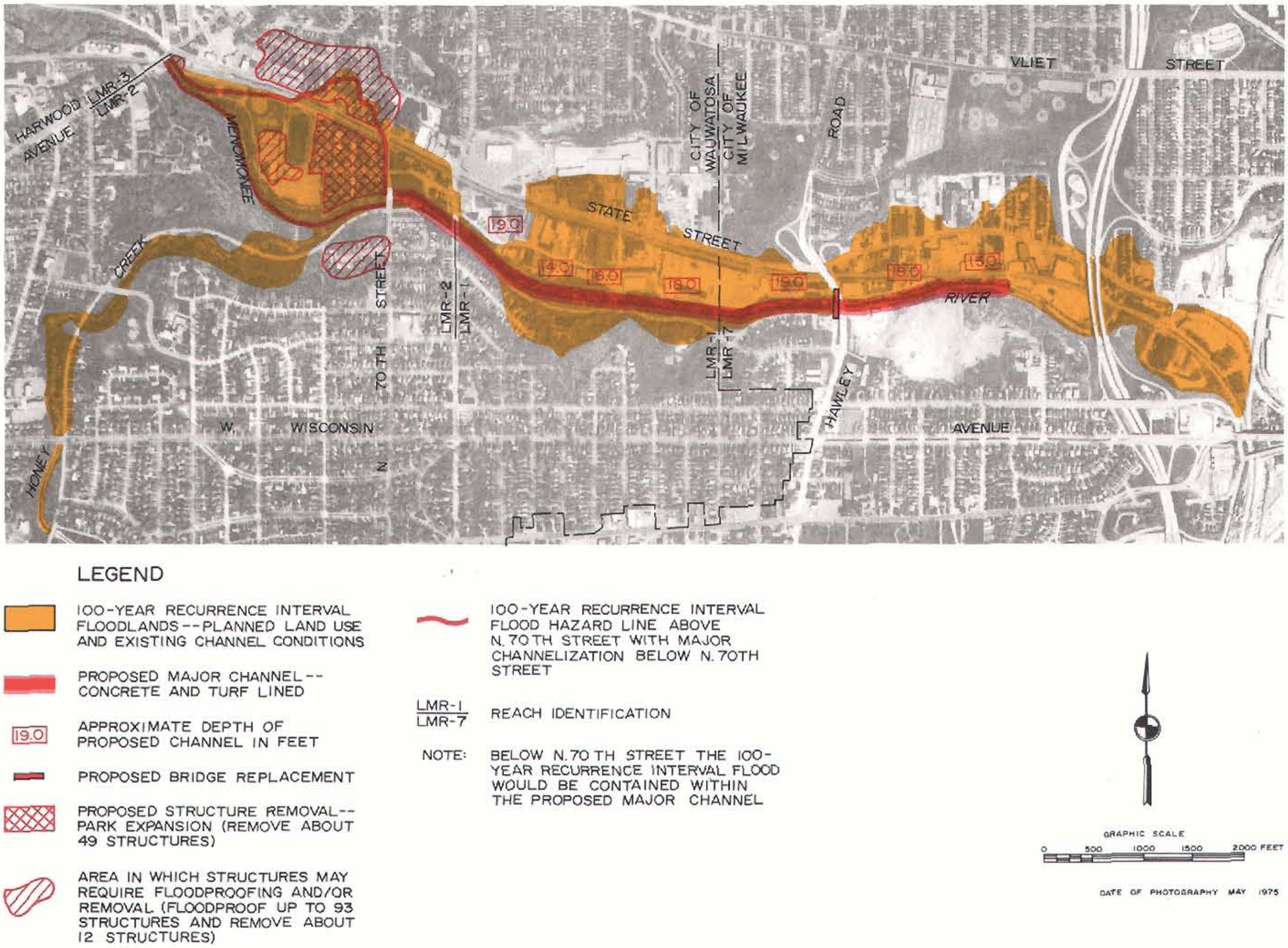
Demolition and reconstruction of the N. 70th Street crossing, in conjunction with downstream channelization, so as to essentially eliminate the backwater effect of that structure, would reduce the 100-year flood stage profile under year 2000 conditions upstream of N. 70th Street bridge by an insignificant amount. Thus, there is no opportunity to reduce the cost of structure floodproofing and removal along the Menomonee River between N. 70th Street and Harwood Avenue by including the demolition and reconstruction of the N. 70th Street bridge in the alternative.

The most cost-effective means of eliminating the primary and secondary flooding along the Menomonee River between the N. 70th Street bridge and Harwood Avenue is to channelize the reach in general conformance with the concepts set forth in the major channel modification alternative discussed above. The equivalent average annual cost of such channelization in this reach, including demolition and reconstruction of the 70th Street bridge, is $92,200 which compares to an equivalent average annual cost of $171,500 for structure floodproofing and removal.

The composite channelization-structure floodproofing and removal alternative would have a potentially negative aesthetic impact on most of the 1.34-mile-long Menomonee River reach within the City of Wauwatosa between N. 70th Street and the Wauwatosa-Milwaukee line inasmuch as one or both sides of the reach are utilized for outdoor recreation and related open space use or for residential use. The attractiveness of the existing natural channel floodplain would be compromised by the extensive cross-section enlargement required for the channelization project and by the placement of the concrete invert and floodwalls. Trees and shrubs lining both sides of the existing channel would have to be removed in order to construct the channel works. The Menomonee River in this reach is lined by a dense but narrow band of trees and shrubs, most of which would have to be removed during construction of the

Map 35

CHANNEL MODIFICATIONS AND STRUCTURE FLOODPROOFING AND REMOVAL ALONG THE MENOMONEE RIVER IN THE CITY OF WAUWATOSA



This alternative measure for flood damage mitigation combines major channelization along the Menomonee River downstream of N. 70th Street with structure floodproofing and removal along the Menomonee River immediately upstream at N. 70th Street. This technically practicable measure, while found to be slightly uneconomic, was recommended for inclusion in the comprehensive plan for the Menomonee River watershed by the watershed committee because, in addition to resolving the major flood problems in this area, retention of the Harwood Avenue-N. 70th Street reach in a "natural" state is consistent with the City of Wauwatosa's intent to renew the Old Village area and the structure removal aspect in the Hart Park area would accommodate a needed expansion of Hart Park.

Source: SEWRPC.

channel works. The aesthetic impact would be very apparent to residents of the adjacent areas as well as to users of the Milwaukee County Parkway and Parkway Drive and Jacobus Park.

The composite channelization-structure floodproofing and removal alternative would, however, have a positive aesthetic effect upstream of N. 70th Street in that it would eliminate the need to drastically alter the Menomonee River channel in this area and would also provide for a 13 acre expansion of the City's Hart Park to the east through the acquisition and removal of flood-prone residential structures in that area. Although the annualized monetary cost of this composite alternative exceeds the annualized benefits, the difference is not large—the average annual benefits are 87 percent of the average annual cost—and, therefore, the intangible but nevertheless real values associated with protecting the aesthetic features of the Menomonee River upstream of N. 70th Street and with the desirable expansion of Hart Park may be judged to offset the unfavorable benefit-cost analysis.

After reviewing the technical, economic, and nontechnical and noneconomic features of the four available alternatives—structure floodproofing and removal, major channel modification, dikes and floodwalls, and the channelization-structure floodproofing and removal composite—the Menomonee River Watershed Committee recommended that the channelization-structure floodproofing and removal alternative be used to resolve existing and forecast flood problems along the Menomonee River in Wauwatosa between the eastern limits of the City and Harwood Avenue.

Three intangible factors ultimately entered into the Watershed Committee's decision to recommend the channelization-structure floodproofing and removal alternative for the Menomonee River in Wauwatosa downstream of Harwood Avenue. First, with implementation of these measures, the Menomonee River channel and riverine area between N. 70th Street and Harwood Avenue, which passes through the "Old Village Center" and its immediate environs, would be retained in its present "natural" condition. This is in harmony with the long-range plans of the Village to rejuvenate the "Old Village Center" focusing on the various amenities associated with the Menomonee River. Second, based in part on a May 1974 report[7] from the Wauwatosa City Planning Division to the City Plan Commission, a need exists for additional outdoor recreational facilities in the immediate area because of inadequate land area and facilities at Hart Park which serves a citywide recreational function including use for school athletic programs. City of Wauwatosa officials estimate that approximately 188,000 individual visits were made to Hart Park in 1975 to use or participate in the variety of outdoor recreational facilities or activities provided there.[8] The structure removal component of the recommended channelization-structure floodproofing and removal alternative would provide 13 acres of additional parkland immediately adjacent to the eastern limits of Hart Park and thereby serve to significantly reduce the crowding and overuse presently experienced at this facility. The third intangible factor entering into the Committee decision to recommend the channelization-structure floodproofing and removal alternative is a long-range solution to the future problem, perceived by the City of Wauwatosa, of decreasing property values in the residential areas bounded by Hart Park on the west, W. State Street on the north, N. 70th Street on the east, and the Menomonee River on the south. A November 1974 report to the City Plan Commission[9] notes that, at that time, the average age of all structures in this area was 59 years. The November 1974 report refers to a 1968 proposal by the City Planning staff to reserve the area bounded by Hart Park on the west, W. State Street on the north, N. 70th Street on the east, and the Menomonee River on the south for future park use. The report notes that this recommendation was based upon three factors: the flood-prone nature of the area, the need for additional outdoor recreational space, and the fact that the area had an "aging housing stock on undersized lots which would be difficult, if not impossible, to upgrade to code standards and may not be economically feasible to rehabilitate in the future".[10]

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[7] *"Report on the Acquisition of Property for the Extension of Hart Park," Prepared by the City Planning Division of Wauwatosa for the City Plan Commission, May 13, 1974, p. 1.*

[8] *April 9, 1976, letter to SEWRPC from J. William Little, City Administrator, Wauwatosa.*

[9] *Report to the Wauwatosa City Plan Commission from the Planning Administrator regarding an application to rezone property, November 8, 1974, p. 6.*

The City of Mequon

The Flood Problem: As shown on Map 15, the City of Mequon contains one flood-prone reach within the Menomonee River watershed, a reach encompassing 1.06 miles of the Little Menomonee River within the City. As a result of direct and indirect flood damages associated with flooding along this reach of the Little Menomonee River, the City may be expected to incur $16,400 in urban flood damages during a 100-year recurrence interval flood under existing and year 2000 plan conditions. Average annual monetary flood risks in this reach attributable to both primary and secondary flooding under existing conditions as well as year 2000 land use and floodland development conditions are estimated at about $2,300. The average annual damages are identical under existing and year 2000 plan condition because the plan anticipates no additional urban development upstream of the flood-prone reach within the Little Menomonee River subwatershed. As discussed earlier in this chapter, complete development of the floodland and nonfloodland portions of the tributary area could be expected to result in an approximately fifteen-fold increase in average annual monetary flood risks. If additional flood-prone development were permitted along Little Menomonee River in the City of Mequon, even higher monetary risks would be incurred.

Floodproofing of Structures: A floodproofing alternative was developed and analyzed to determine if such a structure-by-structure approach would constitute a technically, economically, and environmentally acceptable solution to the flood problem of the City. The design criteria and related assumptions used to develop this alternative were identical to those applied in developing the floodproofing and removal alternative for the Village of Elm Grove. As shown on Map 36, the analyses indicated that about 19 structures located in the primary and secondary flood zones may require some form of floodproofing. Future flood damage attributable to the Little Menomonee River would be virtually eliminated by such floodproofing. Table 30 sets forth a schedule of the approximate number and types of structures to be floodproofed and also summarizes the estimated costs and benefits.

The average annual cost of the structure floodproofing measures computed, using an annual interest rate of 6 percent and a project life amortization period of 50 years, is estimated at about $800, consisting entirely of the amortization of the $12,000 capital costs of the floodproofing. The average annual flood abatement benefit is estimated at about $2,300, yielding a benefit-cost ratio of 2.88 and an excess of annual benefits over costs of about $1,500. Therefore, the structure floodproofing plan element, as described herein, would be both technically and economically feasible within the City of Mequon.

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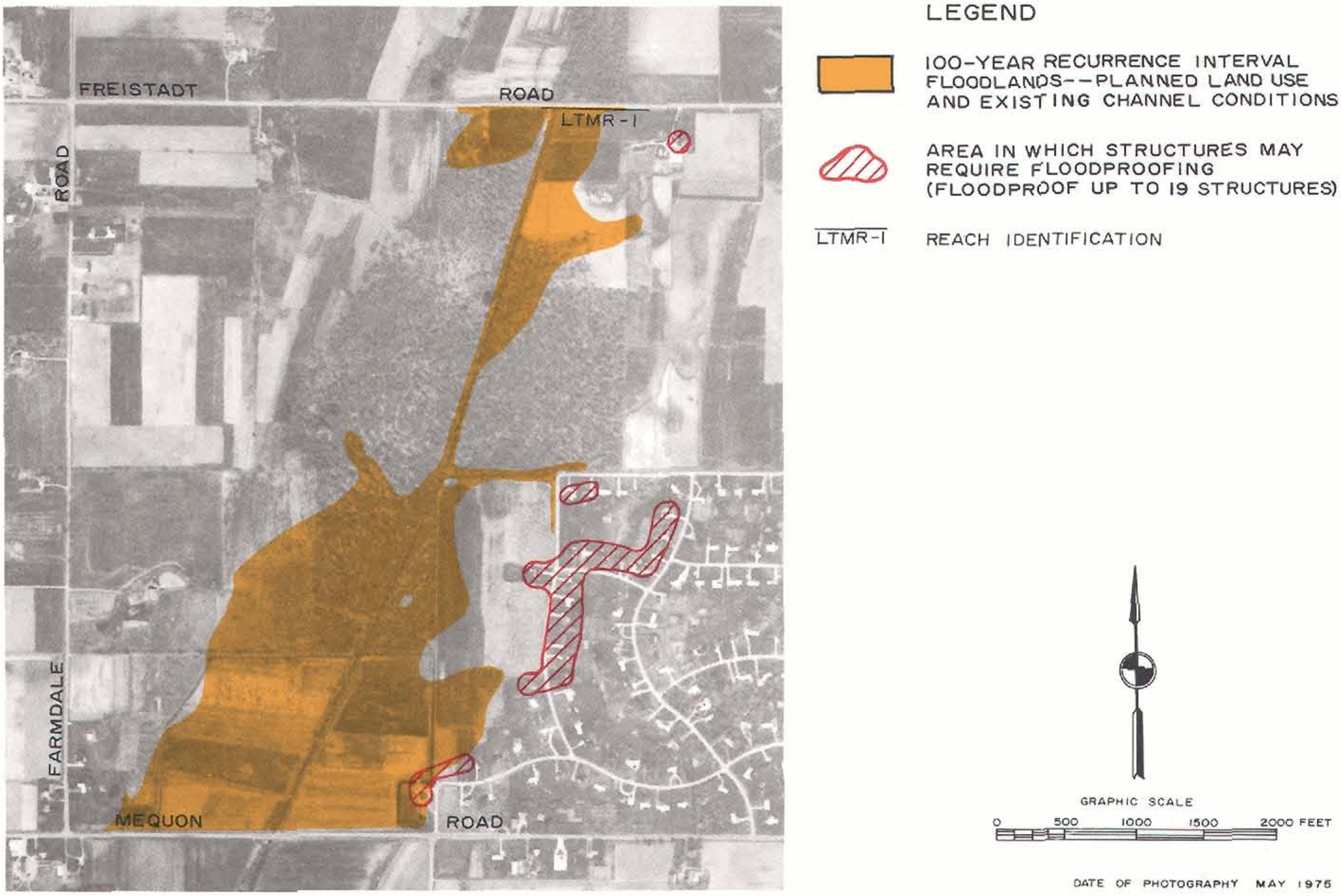
[10] *Ibid, p. 10.*

Map 36

STRUCTURE FLOODPROOFING ALONG THE LITTLE MENOMONEE RIVER IN THE CITY OF MEQUON



Portions of this residential area are subjected to backwater flooding from the Little Menomonee River, a problem that is further aggravated by localized storm water drainage problems. Selective floodproofing of residential structures was examined as one alternative means of resolving this problem and was subsequently recommended for implementation.

Source: SEWRPC.

Dikes: A dike alternative was developed and analyzed for the residential lands subjected to flooding by Little Menomonee River in the City of Mequon to determine if such a structural measure would provide a technically sound, economically viable, and environmentally acceptable solution to the existing and probable future flood problems. The 100-year recurrence interval flood discharge under year 2000 land use plan conditions was used as a basis for a preliminary design of the dikes.

The dike alternative for the Little Menomonee River in Mequon shown on Map 37 and the attendant cost and benefits are presented in Table 30. Under this alternative, a total of 0.8 miles of earthen dikes similar to those shown in Figure 4 would be constructed along the east side of the 0.5-mile-long reach of the Little Menomonee River passing near the residential development. In order to convey the design flood flow with a minimum freeboard of two feet, the earthen dikes would have a maximum height above existing ground level of about three feet.

The dike alternative would not require the reconstruction or modification of any bridges or stream crossings. The dike alternative would, however, include provision for the construction of two storm water pumping stations, equipped with backwater gates, near the end of the storm water drainageways tributary to the Little Menomonee River. These facilities would be required to prevent the movement of floodwaters from the River into the surrounding urban area through these storm water drainageways and to prevent accumulation of lateral runoff behind the dikes and floodwalls creating local drainage problems.

The average annual cost of the dike alternative, computed using an annual interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at $17,600. This cost consists of: amortization of the $96,300 capital costs of the dikes and the land necessary to construct them, amortization of the $130,000 capital costs of backwater control and pumping facilities, and $3,200 in annual operation and maintenance costs. Assuming that

Table 30

PRINCIPAL FEATURES AND COSTS AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE CITY OF MEQUON

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
				Capital Cost		Annual Amortization of Capital Cost	Annual Operation and Maintenance Cost	Total Annual Cost	Annual Benefit	Annual Benefit Minus Annual Cost	Benefit-Cost Ratio	Economically Feasible?			
Number	Name	Description		Item	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)			Positive	Negative	
1	No Action	--	Yes	--	--	--	--	2.3	0.0	- 2.3	0.00	No	--	--	No
2	Detention Storage	100 acre-feet detention reservoir on the Little Menomonee River in the City of Mequon	Yes	Reservoir and associated works	41.7	2.65	1.0	3.65	2.3	1.35	0.63	No	--	--	No
3	Structure Floodproofing	Floodproof up to 19 residential structures	Yes	Floodproofing	12.0	0.8	0.0	0.8	2.3	1.5	2.88	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Local storm water drainage problems likely to remain 3. Some floodproofing is likely to be applied without adequate professional advice, and, as a result, structure damage may occur	Yes
4	Dikes	a. 0.8 miles of dikes b. Install 2 storm-water pumping stations	Yes	Dikes Pumps Subtotal	96.3 130.0[e] 226.3	14.4	3.2	17.6	2.3	- 15.3	0.13	No	--	--	No
5	Bridge and Culvert Alteration or Replacement	Replace the bridge immediately down-stream of the flood-prone reach	No	--	--	--	--	--	--	--	--	--	--	--	No

[a] *Economic analyses are based on an annual interest rate of 6 percent and assume a 50-year amortization period and project life.*

[b] *A preliminary technical and economic assessment of diversion of floodwaters from the lower portion of the watershed to Lake Michigan and temporary storage in mined chambers beneath the watershed indicated that while these would be technically feasible they would be extremely uneconomic means of resolving flood problems in all or portions of the watershed. A preliminary assessment indicated that channelization would be an extremely uneconomic means of resolving the flood problem in the residential area along the Little Menomonee River in Mequon.*

[c] *Economic analyses were not done for technically impractical alternatives.*

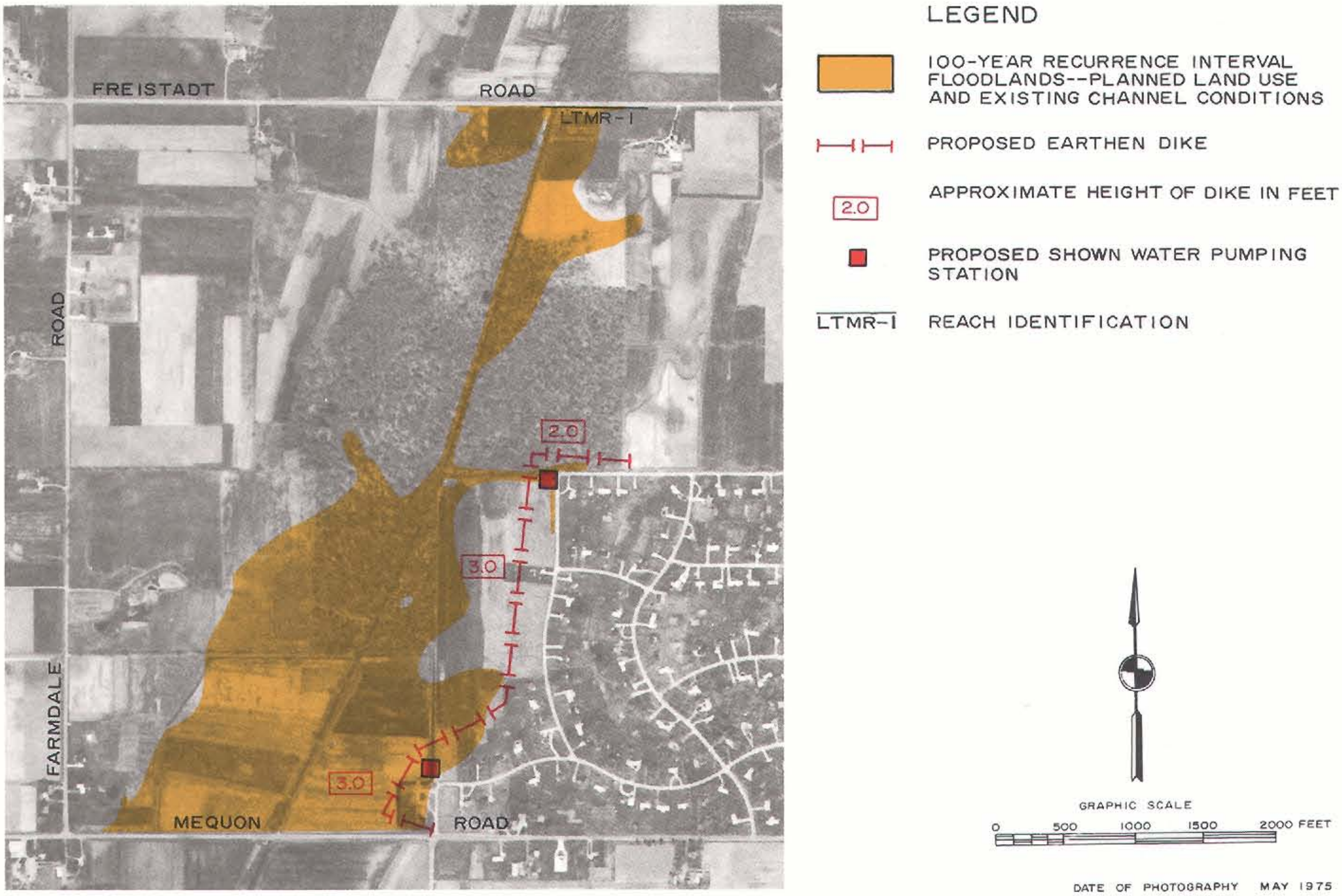
[d] *Presented only for technically and economically feasible alternatives.*

[e] *Present worth cost based on a 25 year economic life.*

Source: SEWRPC.

Map 37

DIKE-FLOODWALL SYSTEM ALONG THE LITTLE MENOMONEE RIVER IN THE CITY OF MEQUON



An earthen dike in combination with storm water pumping stations would achieve substantial reduction in flooding attributed to backwater from the Little Menomonee River and would also help to alleviate local storm water drainage problems in this residential area. Although technically practicable, this alternative was determined to be economically unfeasible.

Source: SEWRPC.

the dike system would completely eliminate all residential flood damages attributable to the Little Menomonee River in the City of Mequon, the average annual flood abatement benefit is estimated at about $2,300, yielding a benefit-cost ratio of 0.13 and an annual excess of costs over benefits of about $15,300. Therefore, the City of Mequon dike alternative plan element, as described herein, may be considered technically feasible but economically unsound.

Bridge and Culvert Alteration or Replacement for Flood Control Purposes: The removal and possible replacement of one or more selected bridges or culverts on Little Menomonee River within the City of Mequon was examined as a potential means of significantly reducing problems to the residential area immediately upstream of Mequon Road (STH 167). The Mequon Road bridge was the only structure having a backwater that could potentially affect the flood stages in the flood-prone reach. Hydraulic analyses based upon the 100-year recurrence interval flood discharge under year 2000 plan conditions indicate that removal or replacement of that bridge could be expected to reduce the 100-year recurrence interval flood stage through the flood-prone reach by approximately 0.5 to 1.0 foot. Based on this hydraulic analysis, it was concluded that removal or replacement of the Mequon Road bridge did not constitute a technically feasible means of significantly reducing the magnitude of flood problem that prevails within the community and, therefore, further technical and economic analysis of this floodland management alternative was not warranted. Inasmuch as the Mequon Road bridge is to be replaced in accordance with the adopted jurisdictional highway system plan for Ozaukee County, some flood relief will accrue to the upstream residential area provided that the new crossing is designed in accordance with the standards set forth in Chapter II of this volume.

Concluding Statement: Three distinctly different structural floodland management alternatives—storage in a detention reservoir as described earlier in this chapter, earthen dikes, and bridge alteration—and one nonstructural measure—structure floodproofing—were examined as possible solutions to the residential area flood problem that exist along the Little Menomonee River immediately north of Mequon Road in the City of Mequon. In addition, a fifth alternative, that of taking no action, is available to the public agencies concerned, and the flood damages attendant to this alternative provided an important basis for an analysis of the potential benefits associated with each of the other alternatives.

The principal features of, and the costs and benefits associated with, each of the floodland management alternatives are summarized in Table 30 together with the major favorable and unfavorable nontechnical and noneconomic considerations likely to influence selection of the most desirable solution. In addition to the alternatives identified in the table, the diversion of flood waters to Lake Michigan and a temporary storage of floodwaters in mined storage chambers beneath watershed were subjected to a preliminary assessment and, although these two alternatives were determined to be technically feasible, both were shown to be economically unsound by a wide margin. A preliminary assessment indicated that channelization would be an extremely uneconomic means of resolving the flood problem in the residential area along the Little Menomonee River in Mequon and therefore further technical and economic analyses of this alternative was not warranted.

All of the structural and nonstructural alternatives identified in Table 30 were found to be technically feasible with the exception of bridge alteration or replacement. Of the remaining measures, only structure floodproofing was found to be economic, with the other measures having unfavorable benefit-cost ratios.

After due consideration of the various technical, economic, and nontechnical and noneconomic features of the available alternatives, it is recommended that floodproofing be employed to resolve existing and forecast flood problems along the Little Menomonee River in the City of Mequon. It is imperative that all floodproofing measures, irrespective of the structure types involved, be applied under the guidance of a registered engineer. Failure to utilize adequate professional supervision is likely to result in damage to the structure during a major flood event.

Based on information obtained during the field surveys conducted in this area subsequent to the April 1973 flood and on examination of topographic conditions, particularly the character of the natural drainageways and roadside drainage swales, it appears probable that this area also experiences drainage problems attendant to storm water runoff originating on high ground to the east of the residential area and flowing through the area enroute to the Little Menomonee River. While the recommended floodproofing should eliminate most of the flood problems directly attributable to high stages on the Little Menomonee River, some storm water drainage problems are likely to remain in the area east of the floodlands.

The City of Milwaukee

The Flood Problem: As shown on Map 15, the City of Milwaukee contains one short flood-prone reach along a 0.93-mile-long portion of the Menomonee River bounded at the downstream end by N. 45th Street at River Mile 4.45 and at the upstream end by N. 60th Street Extended at River Mile 5.38. While very little flood-prone development exists on the south side of this reach of the River, the area north of the River and south of W. State Street which approximately parallels the River in this reach does contain flood-prone industrial and commercial development. In addition, there are some areas of residential development in this reach north of W. State Street that would be affected by a major flood event.

Average annual monetary flood risks attributable to both primary and secondary flooding under existing conditions are estimated at about $38,600 for this reach, whereas the average annual monetary flood risks under year 2000 land use and floodland development conditions are estimated at about $48,600, a 26 percent increase over existing conditions. It should be emphasized that the increase in average annual monetary damages under year 2000 plan conditions is solely attributed to anticipated changes in upstream land use development in the watershed inasmuch as analysis presumes that no new flood-prone structures would be constructed along the Menomonee River in this reach. As discussed earlier in this chapter, complete development of the floodland and nonfloodland portions of the tributary area could be expected to result in approximately a six-fold increase in average annual monetary flood risks in this reach and, if additional flood-prone development were permitted along the Menomonee River in this area, even higher monetary risks would be incurred. As a result of direct and indirect flood damages associated with Menomonee River flooding, this reach may be expected to incur $728,200 in flood damages during a 100-year recurrence interval flood under existing conditions whereas 100-year recurrence interval flood damages under year 2000 plan conditions could be expected to approximate $841,900.

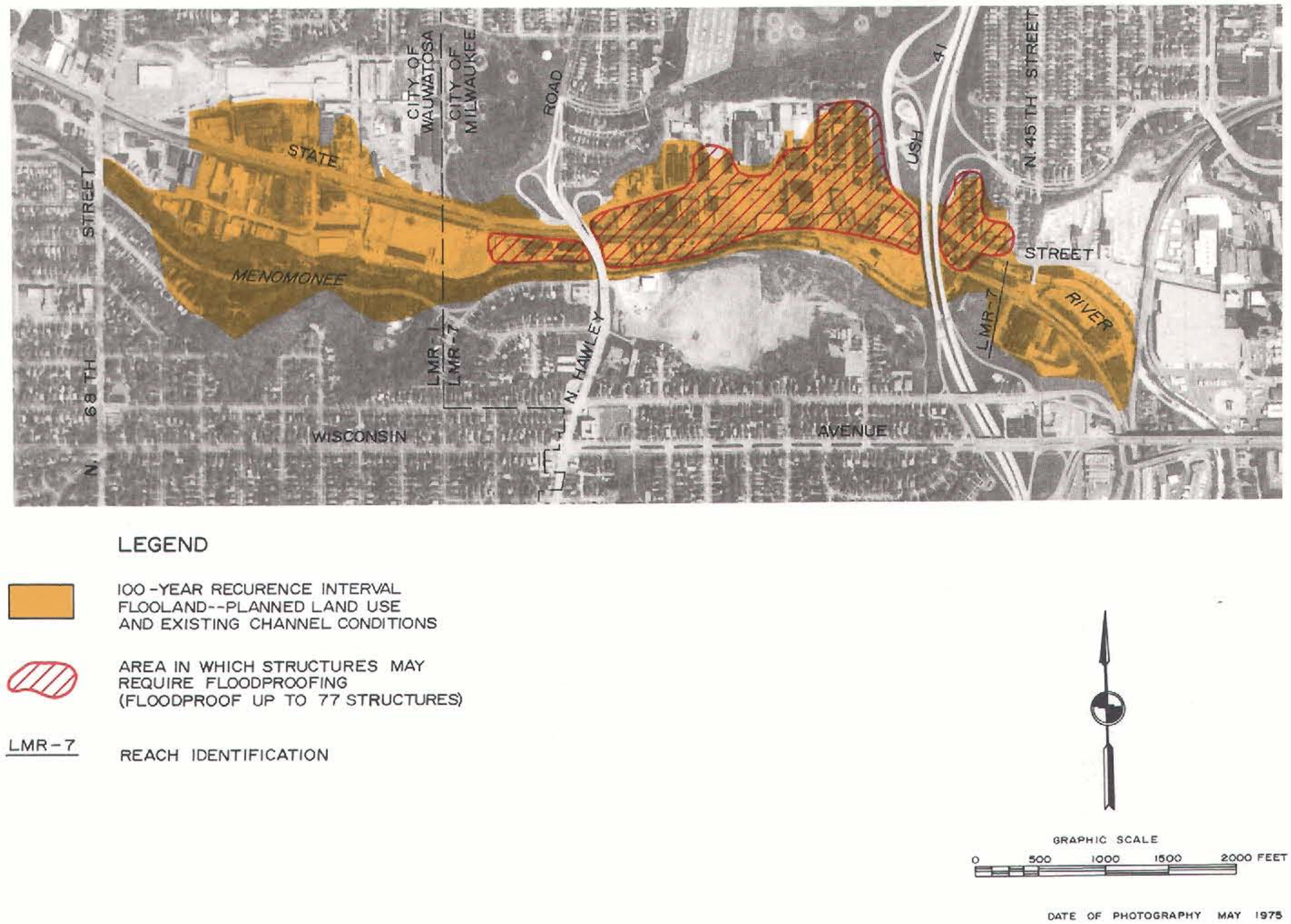
Floodproofing of Structures: A floodproofing alternative was developed and analyzed to determine if such a structure-by-structure approach would be a technically, economically, and environmentally acceptable solution to the flood problem in this Menomonee River reach. The design criteria and overall approach used in this analysis were identical to those applied in the Village of Elm Grove.

As shown on Map 38, the analyses indicated that no structures would have to be removed from the 100-year recurrence interval floodlands under this alternative and a total of about 77 structures located in the primary and secondary flooding zones may require some form of floodproofing. Future flood damage to commercial, industrial, and private residences within this reach would be virtually eliminated by the floodproofing. Table 31 sets forth a schedule of the approximate number and type of structures to be floodproofed and also summarizes the estimated costs and benefits.

Assuming that the aforementioned structure floodproofing measures would be fully implemented and utilizing an annual interest rate of 6 percent and a project life and

Map 38

STRUCTURE FLOODPROOFING ALONG THE MENOMONEE RIVER IN THE CITY OF MILWAUKEE



Structure floodproofing was examined as one alternative means of resolving existing and probable future flood problems along that reach of the Menomonee River between N. 45th Street and N. 60th Street Extended in the City of Milwaukee. Under this floodland management measure, up to 77 structures consisting of 24 commercial-industrial buildings and 53 private residences would be floodproofed. This technically practicable and economically feasible floodland management measure was recommended for inclusion in the watershed plan.

Source: SEWRPC.

amortization period of 50 years, the equivalent average annual cost is estimated at about $20,300, consisting entirely of the amortization of the $320,200 capital cost of the floodproofing. The average annual flood abatement benefit is estimated at about $48,600, yielding a benefit-cost ratio of 2.39 at an excess of annual benefits over cost of about $28,300. Therefore, the structure floodproofing and removal plan element, as described herein, would be both technically and economically feasible along this flood-prone reach of the Menomonee River in the City of Milwaukee.

Channel Modifications: A major channel modification alternative was developed for this flood-prone reach. The channel would be designed to pass the 100-year recurrence interval flood discharge under the year 2000 plan condition with two feet of freeboard. The major channelization alternative shown on Map 39 and the attendant costs and benefits are set forth in Table 31. Under this alternative, major channel improvements would be carried out over a total of 0.7 miles of the Menomonee River. The improved channel would be located along the alignment of the Menomonee River and would extend in an upstream direction from the N. 45th Street crossing at River Mile 4.45—the location of a drop structure marking the present upstream terminus of major channelization along the Menomonee River—to a channel drop structure located at the Hawley Road crossing of the Menomonee River at River Mile 5.15. The channel bottom profile and channel cross sectional shape at the downstream end of the channelized reach would be designed so as to effect an acceptable transition to the channel grade and shape of existing channelized section.

Table 31

PRINCIPAL FEATURES AND COSTS AND BENEFITS OF FLOODLAND MANAGEMENT ALTERNATIVES FOR THE CITY OF MILWAUKEE

Alternative[b]			Technically Feasible?	Economic Analysis[a,c]									Nontechnical and Noneconomic Considerations[d]		Recommended?
				Capital Cost		Annual Amortization of Capital Cost	Annual Operation and Maintenance Cost	Total Annual Cost	Annual Benefit	Annual Benefit Minus Annual Cost	Benefit-Cost Ratio	Economically Feasible?			
Number	Name	Description		Item	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)	(In 1,000 Dollars)			Positive	Negative	
1	No Action	--	Yes	-	-	--	--	48.6	0.0	- 48.6	0.00	No	--	--	No
2	Structure Floodproofing	Floodproof up to 53 residential and 24 commercial and industrial structures	Yes	Floodproofing	320.2	20.3	0.0	20.3	48.6	28.3	2.39	Yes	1. Immediate partial flood relief at discretion of property owners 2. Most of the costs could be borne by beneficiaries	1. Complete, voluntary implementation unlikely and therefore left with a significant residual flood problem 2. Overland flooding and some attendant problems remain 3. Some floodproofing is likely to be applied without adequate professionaladvice and, as a result, structure damage may occur	Yes
3	Major Channel Modification	a. 0.7 miles of major channelization b. Replace 2 stream structures	Yes	Channelization Bridges Subtotal	1,752.8 1,007.0 2,759.8	175.1	0.4	175.5	48.6	- 126.9	0.28	No	1. Opportunity to couple channel work with proposed park development to the south thereby enhancing the appearance of the riverine area	--	No
4	Dikes and Floodwalls	a. 0.60 miles of dike b. 0.40 miles of floodwall c. Replace 3 stream crossings d. Install 4 stormwater pumping stations	Yes	Dikes Floodwalls Bridges Pumps Subtotal	390.8 478.4 1,363.0 260.0[e] 2,492.2	158.2	4.8	163.0	48.6	- 114.4	0.30	No	1. Dike and floodwall will provide a desirable visual screen between the park south of the river and the industrial-commercial area north of the river	--	No
5	Bridge Alteration or Replacement	Alter or replace 2 bridges causing backwater in excess of one foot	No	--	--	--	--	--	--	--	--	--	--	--	No

[a] *A preliminary technical and economic assessment of diversion of floodwaters from the lower portion of the watershed to Lake Michigan and temporary storage in mined chambers beneath the watershed indicated that, while these would be technically feasible, they would be an extremely uneconomic means of resolving flood problems in all or portions of the watershed. A preliminary technical assessment of a system of 11 detention reservoirs revealed that such a system would not be a technically practical method for resolving flood problems within the City of Milwaukee.*

[b] *Economic analyses are based on an annual interest rate of 6 percent and assume a 50 year amortization period and project life.*

[c] *Economic analyses were not done for technically impractical alternatives.*

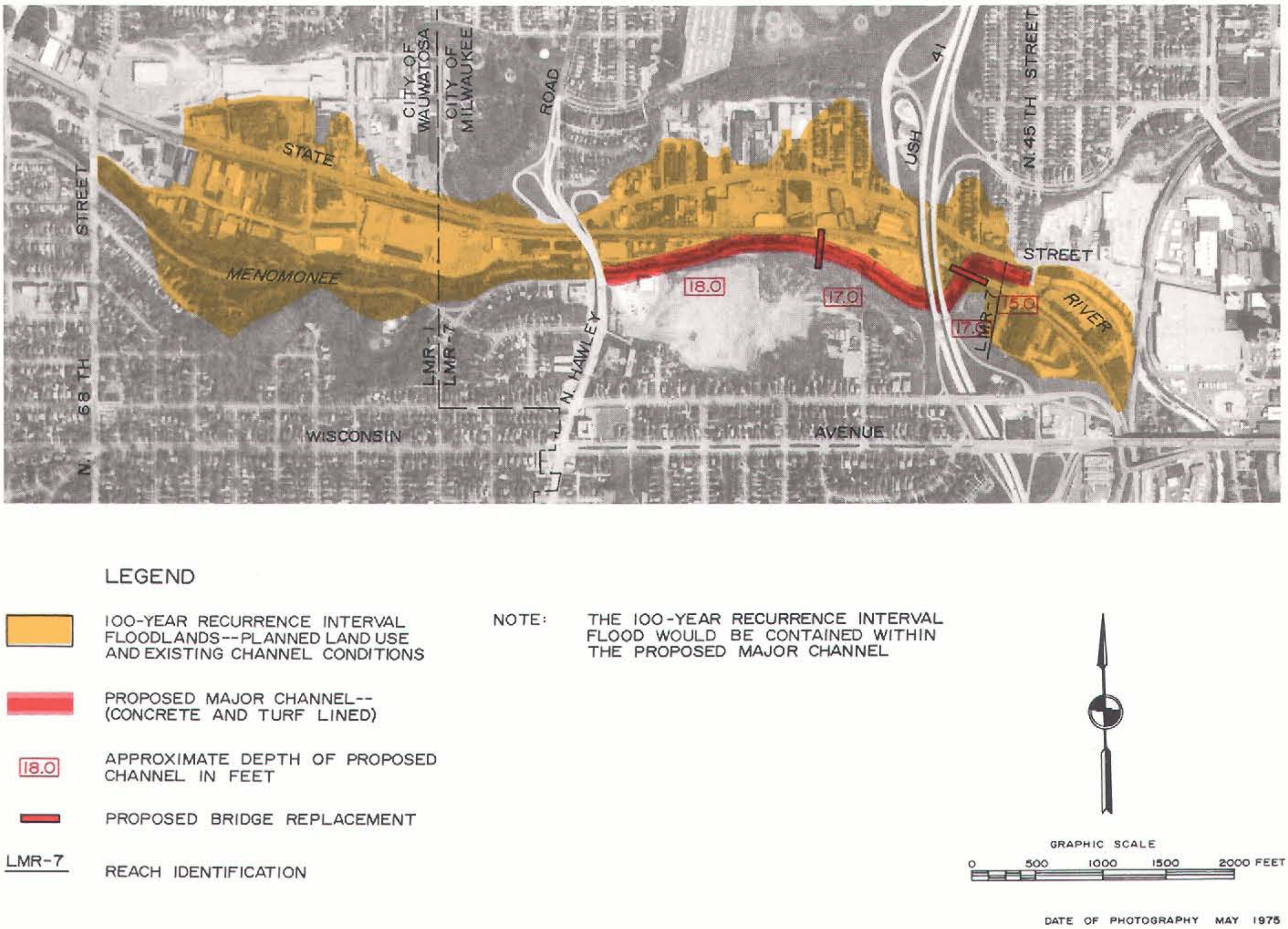
[d] *Presented only for technically and economically feasible alternatives with the exception of alternatives 3 and 4.*

[e] *Present worth cost based on a 25 year economic life.*

Source: SEWRPC.

Map 39

MAJOR CHANNEL MODIFICATIONS ALONG THE MENOMONEE RIVER IN THE CITY OF MILWAUKEE



The possibility of lowering the grade of the Menomonee River channel in the N. Hawley Road-N. 45th Street reach in the City of Milwaukee and widening the channel and lining the bottom and the lower portion of the sidewalls with concrete was examined under the watershed planning program. While this alternative measure would be technically practicable, it was shown to be economically infeasible by a wide margin.

Source: SEWRPC.

Proceeding in a downstream direction, the channelization would lower the existing Menomonee River channel grade by about 2.5 feet in the form of a drop structure on the downstream side of the Hawley Road crossing (River Mile 5.15), about 2.5 feet at the Stadium Freeway crossing (River Mile 4.63), and about 2.0 feet just upstream of N. 45th Street (River Mile 4.45). The width of the invert or bottom of the concrete channel would be about 40 feet and side slopes would be one on three. The bottom and sidewalls of the channel, up to the 10-year recurrence interval flood stage, would be lined with concrete resulting in a total concrete width of approximately 100 feet. The channelization would require replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 4.56 and the private bridge at River Mile 4.83.

In the event that major channelization is carried out along the Menomonee River in the City of Wauwatosa west of Hawley Road, the design of the major channel modification between 45th Street and Hawley Road would be modified so as to eliminate the drop structure at Hawley Road and continue the channelization west of this location thereby providing continuity with the upstream channelization within the City of Wauwatosa. This possible variation on the basic channelization alternative considered for the N. 45th Street-Hawley Road reach would not significantly alter the costs assignable to the reach and therefore would not significantly affect the benefit-costs analyses.

The average annual cost of the major channelization alternative, calculated using an annual interest rate of 6 percent and a project life and amortization period of 50 years, is estimated at about $175,500 consisting of the following: amortization of the $1,752,800 capital cost of the channel modifications, amortization of the $1,007,000 capital cost of bridge demolition and reconstruction, and

$400 in annual operation and maintenance costs. Assuming that the major channelization would completely eliminate all direct and indirect flood damages along the Menomonee River in the City of Milwaukee between N. 45th Street and Hawley Road, the average annual flood abatement benefit is estimated at about $48,600, yielding a benefit-cost ratio of 0.28 and an annual excess of costs over benefits of $126,900. Therefore, although major channelization is technically practicable, it is not economically feasible for that reach of the Menomonee River.

The major channelization proposal could have a negative aesthetic impact on most of the 0.7 mile long reach that would be affected inasmuch as the land to the south between the Stadium Freeway and Hawley Road is intended for park development by the Milwaukee County Park Commission. The aesthetic impact, however, would be minimal inasmuch as the overall riverine development environment under existing conditions is not particularly attractive. With careful design, the channelization proposal would afford an opportunity to actually improve the aesthetic aspects of this reach as viewed from the future park lands on the south by provision of riverine area landscaping in the form of grassy areas, trees, shrubs, and other amenities.

Dikes and Floodwalls: A dike-floodwall alternative was developed for this flood-prone reach with the structures being designed to pass the 100-year recurrence interval flood discharge under year 2000 planned conditions with two feet of freeboard. The dike and floodwall alternative for the Menomonee River reach bounded by N. 45th Street and N. 60th Street extended is shown on Map 40, and the attendant cost and benefit are set forth in Table 31.

Under this alternative a total of 1.0 mile of earthen dikes and concrete or sheet steel floodwalls similar to those shown in Figure 4 would be constructed primarily along the north side of the Menomonee River. About 0.6 mile of earthen dike and about 0.4 mile of concrete or sheet steel floodwall would be required. In order to convey the design flood flow with a minimum freeboard of two feet, the dikes and floodwalls would be quite high in some locations with a maximum height above existing ground level of about 10 feet along the north side of the Menomonee River just upstream of N. 45th Street. The dike and floodwall alternative would require the reconstruction of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 4.56, the private bridge at River Mile 4.83, and the low Hawley Road bridge at River Mile 5.15, in order to contain the floodwaters within the confines of the dikes and floodwalls. In addition, the dike and floodwall alternative would have to include provision for the construction of a minimum of four major storm water lift or pumping stations and installation of backwater gates at or near the ends of the storm sewer outfalls or other drainage ways that are tributary to the Menomonee River. These facilities would be required to prevent the movement of the floodwaters from the River to the surrounding urban area via these storm sewers and drainage ways and to prevent accumulation of lateral runoff behind the dikes and floodwalls, thereby creating local drainage problems.

Assuming that the dike and floodwall alternative would be fully implemented and utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at $163,000 consisting of: amortization of the $869,200 capital costs of the dikes and floodwalls and the land necessary to construct them, amortization of the $1,363,000 capital cost of the new river crossings, amortization of the $260,000 capital cost of the backwater control and pumping facilities, and $4,800 in annual operation and maintenance costs. Assuming that the dike-floodwall system would completely eliminate all direct and indirect flood damages along the Menomonee River between N. 45th Street and Hawley Road, the average annual flood abatement benefit is estimated at about $48,600 yielding a benefit-cost ratio of 0.30 and an annual excess of costs over benefits of about $114,400. Therefore, the dike and floodwall alternative would be technically practicable, but not economically feasible.

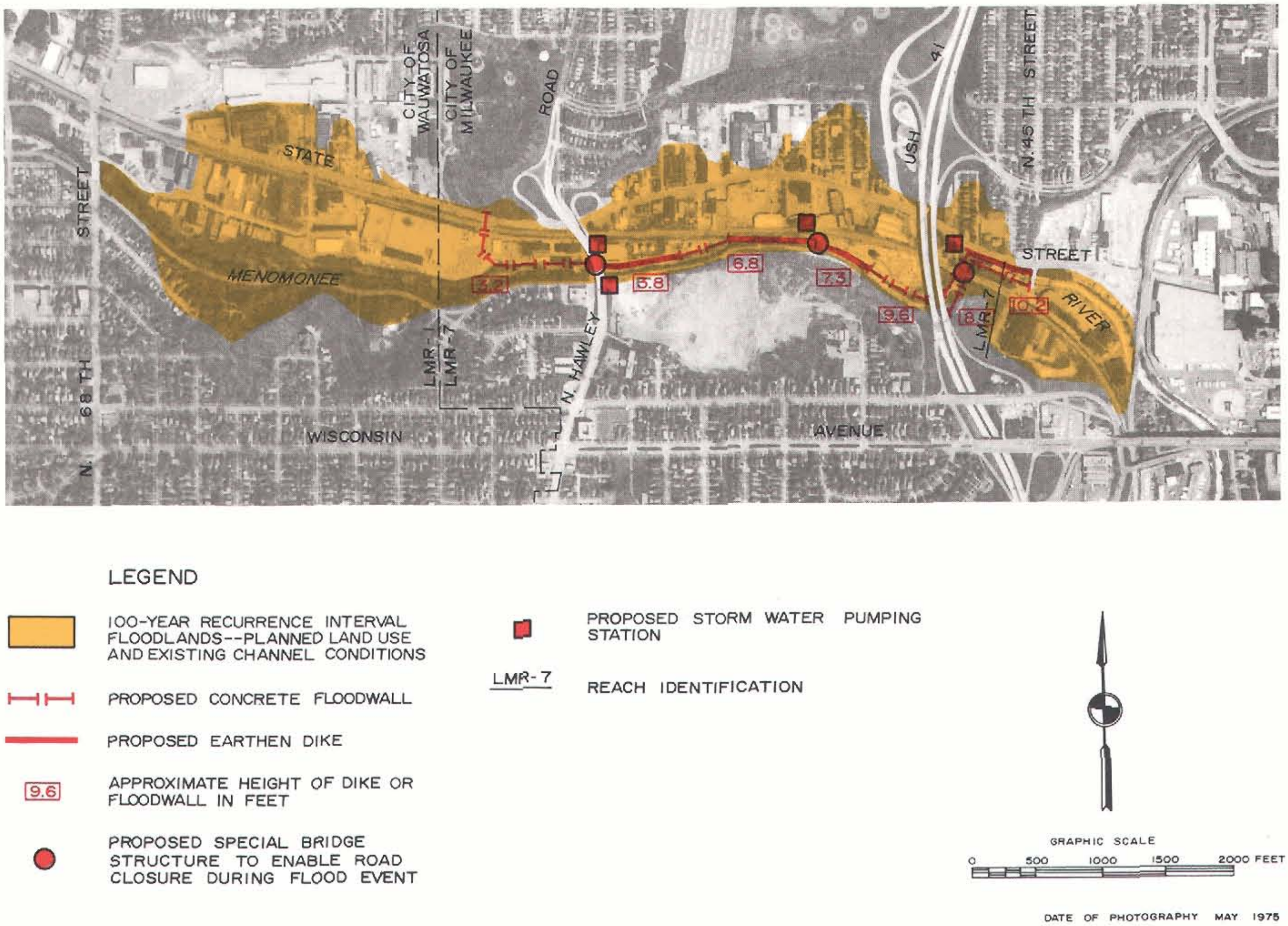
The dikes and floodwalls—most of which would lie along the north edge of the Menomonee River between the Stadium Freeway and Hawley Road—would not cause a significant aesthetic problem when viewed from the north side of the River because of the primarily industrial-commercial uses in that area. The dikes and floodwalls may be regarded as having a positive aesthetic effect inasmuch as they would serve as a visual barrier between the parklands on the south and the industrial-commercial area to the north. A significant negative aspect of the dike and floodwall system is its dependence on the successful operation of backwater gates and pumping facilities and at least four storm water outfalls. In order to assure prompt and proper operation of these facilities, automatic controls would have to be provided and a regular maintenance and testing program instituted.

Bridge or Culvert Alteration or Replacement for Flood Control Purposes: The removal or alteration of selected bridges on the Menomonee River was examined as potential means of significantly reducing the flood problems in the N. 45th Street-Hawley Road reach. Under year 2000 plan-100 year recurrence interval flood discharge conditions, the N. 45th Street bridge at River Mile 4.45 produces a backwater of about 2.7 feet, and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 4.56 produces a backwater of about 4.1 feet. Backwater computations under year 2000 plan-100 year recurrence interval discharge conditions indicate that removal or modification of these two structures so as to essentially eliminate their backwater effects would reduce the 100-year flood stage about 2.3 feet in the vicinity of the Stadium Freeway, 0.1 feet halfway between the Stadium Freeway and Hawley Road, and insignificantly at Hawley Road. Based on these results, it was concluded that bridge modification would not significantly reduce monetary flood risks through the reach and, therefore, further technical and economical analyses of alteration or replacement of the two Menomonee River crossings were not considered warranted.

Concluding Statement: Three distinctly different structural floodland management alternatives—major channel modifications, dikes and floodwalls, and bridge

Map 40

DIKE-FLOODWALL SYSTEM ALONG THE MENOMONEE RIVER IN THE CITY OF MILWAUKEE



A system of dikes and floodwalls, located primarily along the north bank of the Menomonee River, supplemented with storm water pumping stations and bridge alterations, would be a technically practicable way to resolve flooding along the north side of the Menomonee River between approximately N. 60th Street Extended and N. 45th Street in the City of Milwaukee. This alternative measure was, however, shown to be economically infeasible.

Source: SEWRPC.

alteration or replacement--and one nonstructural measure—the combination of structure floodproofing and removal—were examined as possible solutions to the flood problems that exists along the Menomonee River in the City of Milwaukee between N. 45th Street and N. 60th Street extended. In addition, a fifth alternative, that of taking no action, is available to the public agencies concerned, and the flood damages attendant to this alternative provided an important basis for the analysis of the potential benefits associated with each of the other alternatives.

The principal features of, and the costs of benefits associated with, each of the floodland management alternatives are summarized in Table 31 together with the major favorable nontechnical and noneconomic considerations likely to influence selection of the most desirable solutions. In addition to the above alternatives, the diversion of floodwaters to Lake Michigan and the temporary storage of floodwaters and mined storage chambers beneath the watershed were subjected to preliminary assessment and, although these alternatives were technically feasible, both were shown to be economically unsound by a wide margin. Consideration was also given to the use of a system of upstream detention storage facilities to resolve the flood problems in this reach but that alternative was determined to be technically infeasible.

Excluding the "no action" alternative, all four of the remaining alternatives were found to be technically feasible with the exception of bridge alteration or replacement. Of the remaining three measures, only one—structure floodproofing—was found to be economically feasible with the other measures being uneconomic by a wide margin. It is, therefore, recommended that floodproofing be employed to resolve existing forecast flood problems along the Menomonee River between N. 45th Street and N. 60th Street extended in the City of Milwaukee. It is imperative that all floodproofing measures, irrespective of the structure types involved, be applied under the guidance of a registered engineer. Failure to utilize adequate professional supervision is likely to result in damage to the structure during a major flood event.

Watershedwide Effects of Recommended Channel Modifications and Detention Storage

The recommended floodland management element of the watershed plan includes the following primarily structural flood control measures, as shown on Map 41, for the abatement of the existing, and for the avoidance of new, flood problems in the Menomonee River watershed:

- The construction of a 215 acre-foot flood detention reservoir on the Dousman Ditch in the City of Brookfield.
- The construction of 1.14 miles of intermediate channel improvements—consisting of a turf-lined channel designed to convey the 100-year recurrence interval flood flow under year 2000 plan conditions—and attendant necessary bridge and culvert modification along Underwood Creek between Juneau Boulevard and W. North Avenue in the Village of Elm Grove.
- The construction of 0.91 miles of major channel improvements—consisting of a concrete-lined channel designed to convey the 100-year recurrence interval flood flow under year 2000 plan conditions—and attendant necessary bridge and culvert modifications along Underwood Creek between Juneau Boulevard and the Waukesha-Milwaukee County line in the Village of Elm Grove.
- The construction of 1.22 miles of major channel improvements—consisting of a concrete-lined channel designed to convey the 100-year recurrence interval flood flow under year 2000 plan conditions—and attendant necessary bridge and culvert modifications along the Menomonee River between N. 70th Street and a point about 0.25 miles downstream of Hawley Road in the City of Wauwatosa and the City of Milwaukee.
- The construction of a total of 4.6 miles of major channel improvements and attendant necessary bridge and culvert modifications along three reaches of the main stem of the Menomonee River in the Village of Menomonee Falls consisting more specifically of 1.36 miles of turf-lined channel between the Washington-Waukesha County line and STH 74; 0.60 miles of concrete-lined channel between Arthur Avenue and Margaret Drive extended; and 2.64 miles of turf-lined channel between Margaret Drive extended and the Waukesha-Milwaukee County line, all designed to convey the 100-year recurrence interval flood flow under year 2000 plan conditions in floodprone reaches.
- The construction of a total of 2.97 miles of major channel improvements and attendant necessary bridge and culvert modifications along two reaches of Lilly Creek downstream of W. Silver Spring Drive within the Village of Menomonee Falls, consisting more specifically of 1.42 miles of turf-lined channel between W. Silver Spring Drive and Oakwood Drive extended and 1.55 miles of concrete-lined channel between Oakwood Drive extended and the confluence with the Menomonee River, all designed to convey the 100-year recurrence interval flood flow under year 2000 plan conditions.

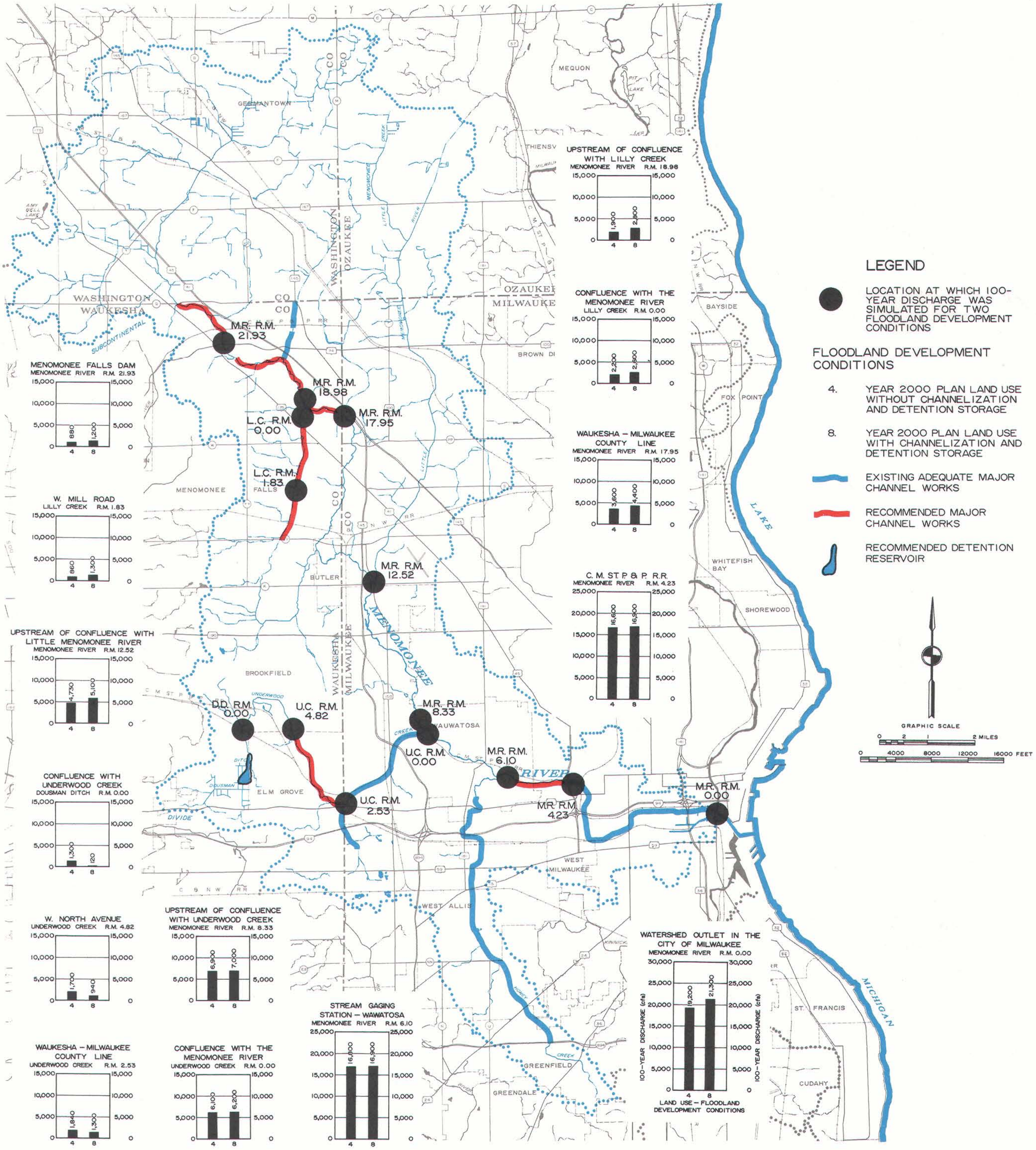
Therefore, in addition to the construction of a detention reservoir, the construction of a total of 10.84 miles of major or intermediate channel modifications is recommended within the Menomonee River watershed between 1976 and the year 2000. The major channel modification work is in addition to the 18.3 miles of major channel modifications—consisting of 15.8 miles of concrete-lined channel and 2.5 miles of underground conduit—that already exist in the Menomonee River watershed stream system primarily within the Milwaukee County portion of the watershed.

Earlier sections of this chapter discussed the hydrologic-hydraulic consequences and flood damage effects of alternative land use-floodland development conditions and demonstrated that extensive floodland development in the watershed, whether through floodland fill up to the channel limits or through stream channelization, can markedly increase flood flows, flood stages, and flood damages. There is, therefore, cause for concern over the expected long-term impact of the recommended structural flood control measures—channelization and detention storage—on downstream flood flows, flood stages, and flood damages. Moreover, analysis of the expected effect of recommended structural flood control measures on flood flows and stages is required by the adopted water control facility development objectives and standards, particularly the standard which states that the upstream and downstream effect of structural flood control works and flood discharges and stages shall be determined and, if the flood control works significantly increase upstream or downstream discharges or stages, such works shall be used only in conjunction with complementary facilities for the storage and movement of the incremental flood waters through the watershed stream system.

Accordingly, the simulation model was used to assess the impact of the recommended channel modifications and detention storage on a full range of flood flows by comparing flood flows at selected locations in the watershed under year 2000 planned land use-floodland development conditions with and without the recommended channel modifications and detention storage. This analysis was initiated with the idea that, if the recommended structural flood control works produced a significant impact on

Map 41

THE EFFECTS OF CHANNELIZATION AND DETENTION STORAGE ON 100-YEAR RECURRENCE INTERVAL FLOODFLOWS IN THE MENOMONEE RIVER WATERSHED



An analysis was conducted under the watershed planning program to quantitatively determine the net impact of the recommended 10.84 miles of channel modifications and the 215 acre-foot detention storage reservoir on a full range of floodflows throughout the watershed. The results are displayed on this map comparing floodflows at selected locations in the watershed under year 2000 plan land use-floodland development conditions with and without the recommended structural flood control works. The analysis indicates that the recommended structural flood control works may be expected to result in from a 90 percent decrease to a 50 percent increase in 100-year recurrence interval peak flood discharges. There should, however, be no significant adverse effects associated with those increases primarily because the recommended channel works would be sized and constructed so as to safely contain and convey the increased flood flows.

downstream flood flows in flood-damage-prone reaches, then subsequent analyses would be conducted to determine the associated impact on flood stages and, if necessary, on flood damages.

Procedure: The analytic procedure was very similar to that used to determine the hydrologic and hydraulic consequences of alternative land use-floodland development. More particularly, the simulation model applications made earlier with the Hydrologic Submodel and Hydraulic Submodel 1 for year 2000 plan land use and floodland development conditions—65 percent urban land use and 35 percent rural land use outside of the floodlands with, relative to 1975 conditions, no additional floodland development or channelization—were altered so as to incorporate the effects of the recommended detention storage and the recommended 10.84 miles of additional channel modifications. The objective of this additional simulation model application was to compare flood flows at selected locations for year 2000 plan land use and floodland development conditions without the detention storage and channelization to flood flows under plan conditions with the detention storage and channelization presumed completed in order to investigate the incremental effect of the recommended structural flood control measures. It is important to note that the analysis of year 2000 plan land use and floodland development conditions without the recommended detention storage and channelization includes those channel modifications already existing in the watershed.

The full available meteorological data base consisting of 35 years of data were used as input to the model so as to yield corresponding flood flows for the 35-year period at 14 selected points on the watershed stream system as shown on Map 41. The 14 locations selected for comparison of flood flows were chosen to be representative of reaches along the watershed stream system that are within or immediately downstream of reaches in which structural floodland management measures are recommended and, therefore, might exhibit changes in flood flow characteristics as a result of the structural flood control elements. The series of flood flows obtained by simulation at each of the 14 sites was used to develop Log Pearson Type III discharge-frequency relationships for each location from which the 5-, 10-, 25-, 50-, 100-, and 500-year recurrence interval flood flow discharges were obtained.

Results: Table 32 presents flood flows for each of the 14 selected sites under year 2000 land use-floodland development conditions with and without the recommended detention storage and channelization. The 100-year flood flow discharges under the two conditions are presented and compared graphically on Map 41. Based on the data set forth in Table 32 and Map 41, the following conclusions may be drawn concerning the watershedwide effect of the recommended detention storage and channelization on flood flows:

1. The ratio of 100-year recurrence interval flood discharges under year 2000 planned land use conditions with the recommended channelization and detention storage to 100-year recurrence interval discharges under year 2000 planned land use conditions without the recommended structural flood control works ranges from a low of 0.1 to a maximum of 1.5 for the 14 selected locations on the watershed stream system.
2. The largest increase in 100-year flood discharges—10 to 50 percent—may be expected along that reach of the Menomonee River within the Village of Menomonee Falls as a result of the channelization recommended within the Village. This increase would not have a significant detrimental impact since the channel works would be designed so as to safely convey the increased flow throughout most of this reach and since affected riverine areas not slated for channel works are generally not occupied by flood-prone development.
3. A 20 to 30 percent increase in 100-year recurrence interval discharges is anticipated along the length of Lilly Creek in the Village of Menomonee Falls as a result of the recommended channelization of that stream. The channel works would be designed to safely convey the increased 100-year recurrence interval discharge thereby negating any adverse effects of the increased discharge.
4. The overall or net hydrologic impact of the recommended structural flood control works on the Menomonee River watershed stream system may be assessed by examining the simulation results at the mouth of the watershed, that is, at the confluence of the Menomonee and Milwaukee Rivers. A 100-year flood flow increase under year 2000 planned land use conditions of only 10 percent may be expected at that location as a result of the construction of 10.84 miles of major channel works and a 215 acre-foot detention reservoir within the watershed.
5. The largest anticipated decrease in 100-year recurrence interval flood flows under year 2000 plan conditions is an approximately 90 percent decrease on Dousman Ditch immediately above its confluence with Underwood Creek in the City of Brookfield. This marked decrease reflects the desired hydrologic impact of the recommended upstream detention reservoir.
6. The net effect on the entire length of Underwood Creek of the detention storage on Dousman Ditch—a tributary to Underwood Creek—and the recommended 2.05 miles of major channel modifications along Underwood Creek within the Village of Elm Grove is a 0 to 40 percent decrease in 100-year recurrence interval flood flows.
7. With few exceptions, the recommended structural flood control works have, for a given location on the watershed stream system, the same relative impact they have on the full range of flood flows, that is, on the 5- to 500-year recurrence interval discharges.

Concluding Statement: The above analysis indicates that the recommended structural flood control works may be expected to result in from a 90 percent decrease to a 50 percent increase in 100-year recurrence interval peak flood discharges under year 2000 planned land use conditions in the Menomonee River watershed. The increased flood flows occur within or immediately downstream of stream reaches for which major channelization is recommended. There should, however, be no significant adverse effects associated with increases in discharge within reaches recommended for channelization since the recommended channel works would be sized and constructed so as to safely contain and convey the flood flows. Furthermore, there should not be any significant adverse effects associated with increases in flood flows at the downstream end of channelized reaches because: 1) the Menomonee River channelization in the City of Wauwatosa will not increase flood flows; 2) the Underwood Creek channelization in the Village of Elm Grove will, in combination with upstream storage, actually yield decreased flood flows; 3) the 20 percent increase in 100-year flood flows from a channelized Lilly Creek in the Village of Menomonee Falls can be readily accommodated in the hydraulic design of the channel works for the Menomonee River at the Lilly Creek-Menomonee River confluence; 4) the 40 percent increase in 100-year flood flows on the Menomonee River at the Menomonee Falls Dam can probably be accommodated by existing conveyance capacity through the steep, essentially unoccupied floodlands in the reach immediately downstream of the Dam; and 5) the 20 percent increase in 100-year flood flows on the Menomonee River at the Waukesha-Milwaukee County line can be readily conveyed through the wide expanse of Milwaukee County parklands immediately downstream of this location.

BRIDGE AND CULVERT ALTERATION OR REPLACEMENT FOR TRANSPORTATION PURPOSES

As indicated earlier in this chapter, bridges and culverts that are inadequately designed from a hydraulic perspective can significantly increase flood stages and areas of inundation and are also subject to closure during major flood events, thereby adversely affecting the function of the regional highway transportation system. The above community-by-community discussion of structural floodland management alternatives included a search for bridges that may aggravate existing flood problems. The purpose of this section of the chapter is to identify those bridges and culverts that could be expected, by virtue of inadequate hydraulic capacity and overtopping of the approach roads or the structure, to interfere with the operation of the highway and railroad transportation system during major flood events.

The watershed development objectives and supporting principles and standards set forth in Chapter II of this volume specify that bridges shall accommodate, according to the categories listed below, the designated flood events without overtopping of the related roadway or railroad track and without resultant disruption of traffic floodwaters. The categories and designated flood events are:

1. Minor and collector streets, used or intended to be used primarily for access to abutting properties—a 10- year recurrence interval flood discharge.

2. Arterial streets and highways, other than freeways and expressways, used or intended to be used primarily to carry heavy volumes of fast, through traffic—a 50-year recurrence interval flood discharge.

3. Freeways, expressways, and railroads—a 100-year recurrence interval flood discharge.

It is evident that the severity of the flood to be passed by a bridge or culvert without overtopping increases in proportion to the importance of the crossing in the regional transportation system. The relative importance or functional classification of each roadway river crossing, that is, minor or collector streets, arterial streets and highways, and freeways and expressways, is established by the SEWRPC year 2000 regional land use-transportation plan. The bridge standards are intended to assure that a sufficient number of critical river crossings will remain passable during major flood events so that the regional highway and railroad transportation system can function properly.

Information contained within the hydrologic-hydraulic summary tables set forth in Appendix E of this volume in combination with the above bridge standards was used to identify the existing bridges and culverts in the watershed that have substandard capacity for being useable during major flood events. As set forth in Table 33, 48 bridges and culverts may be expected to have substandard hydraulic characteristics under year 2000 plan conditions; and it is recommended that, when they are modified or replaced by local or state highway agencies or by railroads as a part of highway and railroad improvement programs, these crossings should be designed to provide adequate capacity in accordance with recommended standards. Of the total number of substandard bridges and culverts, 16 are located on minor or collector street where the 10-year recurrence interval standard is applicable; 21 are located on arterial streets and highways (other than freeways and expressways) where the 50-year recurrence interval standard is applicable; and 11 are located on freeways, expressways, and railroads where the 100-year recurrence interval standard is applicable. Of these 48 structures, one has been identified as causing significant aggravation of existing flood problems; that is the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge in the City of Brookfield on Underwood Creek at River Mile 6.32 near Pilgrim Road. Benefit-cost analyses were not considered as a valid factor in evaluating bridge or culvert modification or replacement because many of the affected structures are nearing the end of their useful lives and will, in any case, require modification or replacement for transportation system improvement or maintenance purposes.

The location, as well as the design, of all new bridges and culverts—that is, of structures proposed to be located over major streams at points within the watershed where

Table 32

HYDROLOGIC-HYDRAULIC EFFECT OF RECOMMENDED CHANNELIZATION AND DETENTION STORAGE

Location			Recurrence Interval (Years)	Year 2000 Land Use-Floodland Development Conditions Without Channelization and Detention Storage	Year 2000 Land Use-Floodland Development Conditions With Channelization and Detention Storage	
Stream	River Mile	Description		Discharge (cfs)	Discharge (cfs)	Relative to Year 2000 Conditions Without Channelization and Detention Storage (Ratio)
Menomonee River	0.00	Watershed Outlet in the City of Milwaukee	5	8,800	9,700	1.1
			10	10,900	12,000	1.1
			25	13,900	15,400	1.1
			50	16,400	18,200	1.1
			100	19,200	21,300	1.1
			500	26,800	30,000	1.1
Menomonee River	4.23	Chicago, Milwaukee, St. Paul, and Pacific Railroad in the City of Milwaukee	5	7,300	6,900	0.9
			10	9,100	8,800	1.0
			25	11,800	11,600	1.0
			50	14,100	14,100	1.0
			100	16,600	16,900	1.0
			500	23,900	25,000	1.0
Menomonee River	6.10	Streamflow Gaging Station in the City of Wauwatosa	5	7,300	6,900	0.9
			10	9,100	8,800	1.0
			25	11,800	11,600	1.0
			50	14,100	14,100	1.0
			100	16,800	16,900	1.0
			500	24,300	25,000	1.0
Menomonee River	8.33	Immediately Upstream of the Confluence with Underwood Creek in the City of Wauwatosa	5	3,490	3,500	1.0
			10	4,230	4,300	1.0
			25	5,250	5,300	1.0
			50	6,050	6,100	1.0
			100	6,900	7,000	1.0
			500	9,100	9,200	1.0
Menomonee River	12.52	Immediately Upstream of the Confluence with the Little Menomonee River in the City of Milwaukee	5	2,300	2,500	1.1
			10	2,830	3,000	1.1
			25	3,550	3,800	1.1
			50	4,130	4,500	1.1
			100	4,730	5,100	1.1
			500	6,300	6,800	1.1
Menomonee River	17.95	Waukesha-Milwaukee County Line upstream of W. Good Hope Road	5	1,850	2,100	1.1
			10	2,200	2,600	1.2
			25	2,800	3,300	1.2
			50	3,200	3,800	1.2
			100	3,600	4,400	1.2
			500	4,600	5,800	1.3
Menomonee River	18.98	Immediately Upstream of the Confluence with Lilly Creek in the Village of Menomonee Falls	5	1,100	1,400	1.3
			10	1,300	1,800	1.4
			25	1,500	2,200	1.5
			50	1,700	2,500	1.5
			100	1,900	2,800	1.5
			500	2,400	3,600	1.5

Table 32 (continued)

Location			Recurrence Interval (Years)	Year 2000 Land Use-Floodland Development Conditions Without Channelization and Detention Storage	Year 2000 Land Use-Floodland Development Conditions With Channelization and Detention Storage	
Stream	River Mile	Description		Discharge (cfs)	Discharge (cfs)	Relative to Year 2000 Conditions Without Channelization and Detention Storage (Ratio)
Menomonee River	21.93	Menomonee Falls Dam in the Village of Menomonee Falls	5	480	670	1.4
			10	580	790	1.4
			25	700	950	1.4
			50	790	1,100	1.4
			100	880	1,200	1.4
			500	1,100	1,400	1.3
Lilly Creek	0.00	At the Confluence with the Menomonee River in the Village of Menomonee Falls	5	860	1,000	1.2
			10	1,100	1,300	1.2
			25	1,500	1,800	1.2
			50	1,800	2,200	1.2
			100	2,200	2,600	1.2
			500	3,200	3,900	1.2
Lilly Creek	1.83	W. Mill Road in the Village of Menomonee Falls	5	350	440	1.3
			10	440	590	1.3
			25	590	830	1.4
			50	710	1,100	1.5
			100	860	1,300	1.5
			500	1,300	2,200	1.7
Underwood Creek	0.00	At the Confluence with the Menomonee River in the City of Wauwatosa	5	2,200	2,100	1.0
			10	2,900	2,800	1.0
			25	4,000	3,900	1.0
			50	4,900	5,000	1.0
			100	6,100	6,200	1.0
			500	9,600	10,200	1.1
Underwood Creek	2.53	Waukesha-Milwaukee County Line Immediately Upstream of the Confluence with the South Branch of Underwood Creek	5	640	400	0.6
			10	845	560	0.7
			25	1,170	790	0.7
			50	1,480	1,000	0.7
			100	1,840	1,300	0.7
			500	2,980	2,200	0.7
Underwood Creek	4.82	W. North Avenue in the City of Brookfield	5	560	320	0.6
			10	750	430	0.6
			25	1,100	600	0.5
			50	1,400	750	0.5
			100	1,700	940	0.6
			500	2,900	1,500	0.5
Dousman Ditch	0.00	At the Confluence with Underwood Creek in the City of Brookfield	5	450	100	0.2
			10	600	100	0.2
			25	830	110	0.1
			50	1,100	110	0.1
			100	1,300	120	0.1
			500	2,100	130	0.1

Source: SEWRPC.

Table 33

RIVER CROSSINGS IN THE MENOMONEE RIVER WATERSHED HAVING SUBSTANDARD HYDRAULIC CAPACITIES

Structure Identification[a]					Date of Construction of Major Reconstruction	Recommended Design Frequency (Years)	Hydraulic Inadequacy	
Stream	Number[b]	Name	River Mile	County			Approach Road Overtopped	Bridge Deck Overtopped
Lower Menomonee River	530	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.87	Milwaukee	N/A[d]	100	X	
	535	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.91	Milwaukee	N/A	100	X	
	540	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.95	Milwaukee	N/A	100	X	
	542	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.97	Milwaukee	N/A	100	X	
	590	Chicago, Milwaukee, St. Paul, and Pacific Railroad	4.24	Milwaukee	N/A	100	X	
	605	Chicago, Milwaukee, St. Paul, and Pacific Railroad	4.56	Milwaukee	N/A	100	X	X
	630	N. 68th Street	5.96	Milwaukee	N/A	50	X	
	635	N. 70th Street	6.10	Milwaukee	N/A	10	X	
	640	Chicago, Milwaukee, St. Paul, and Pacific Railroad	6.70	Milwaukee	1905	100	X	X
	650	Swan Boulevard	8.00	Milwaukee	N/A	50	X	X
	660	North Avenue	8.50	Milwaukee	1934	50	X	
Honey Creek	950	Honey Creek Parkway	0.17	Milwaukee	--	10	X	X
	965	Wisconsin Avenue	0.91	Milwaukee	--	10	X	X
Underwood Creek	1202	Chicago, Milwaukee, St. Paul, and Pacific Railroad	0.81	Milwaukee	1947	100	X	X
	1270	Wall Street	3.25	Waukesha	N/A	10	X	
	1275	Watertown Plank Road	3.43	Waukesha	N/A	50	X	X
	1290	Chicago, Milwaukee, St. Paul, and Pacific Railroad	3.55	Waukesha	1910	100	X	
	1295	Juneau Boulevard	3.67	Waukesha	N/A	10	X	X
	1300	Village Hall Bridge	3.76	Waukesha	N/A	10	X	X
	1305	Marcella Avenue	4.48	Waukesha	N/A	10	X	X
	1310	North Avenue	4.82	Waukesha	N/A	50	X	X
	1315	Clearwater Drive	5.59	Waukesha	N/A	10	X	
	1320	Santa Maria Court	5.99	Waukesha	N/A	10	X	X
	1330	Indian Creek Parkway	6.20	Waukesha	N/A	10	X	X
	1335	Chicago, Milwaukee, St. Paul, and Pacific Railroad	6.32	Waukesha	N/A	100	X	
	1350	Pilgrim Parkway	6.68	Waukesha	N/A	50	X	
South Branch Underwood Creek	1800	W. Bluemound Road	0.05	Waukesha	1962	50	X[c]	
Dousman Ditch	1360	North Avenue	0.06	Waukesha	N/A	50	X	
Little Menomonee River	1425	W. Mill Road	2.41	Milwaukee	N/A	50	X	
	1435	W. Leon Terrace	2.62	Milwaukee	1965	10	X	X
	1485	County Line Road	6.91	Milwaukee-Ozaukee	N/A	50	X	
Upper Menomonee River	870	River Lane	25.98	Washington	N/A	50	X	
	880	Freistadt Road	27.17	Washington	N/A	50	X	
Butler Ditch	1615	Hampton Road	1.02	Waukesha	N/A	50	X	X
	1620	Lisbon Road	1.35	Waukesha	N/A	50	X	
Lilly Creek	3110	Appleton Avenue	0.40	Waukesha	1971	50	X	
	3120	Good Hope Road	0.84	Waukesha	N/A	50	X	X
	3130	Brentwood Drive	1.06	Waukesha	N/A	10	X	X
	3140	Lilly Road	1.80	Waukesha	N/A	50	X	
	3150	Mill Road	1.88	Waukesha	N/A	50	X	X
	3185	Kaul Avenue	2.43	Waukesha	N/A	10	X	X
	3190	Bobolink Avenue	2.48	Waukesha	N/A	10	X	X
	3200	Silver Spring Road	2.97	Waukesha	N/A	50	X	X
Nor-X-Way Channel	3400	Fond du Lac Avenue	0.07	Waukesha	N/A	50	X	X
	3410	USH 41 and 45	0.17	Waukesha	N/A	100	X	X
	3420	Stanley Drive	0.27	Waukesha	N/A	10	X	
Willow Creek	3300	Maple Road	0.06	Washington	N/A	50	X	
North Branch Menomonee River	2905	Holy Hill Road	0.63	Washington	N/A	10	X	

[a] *This table identifies public bridges and culverts which, when considered in conjunction with their approach roadways, have substandard hydraulic capacities under year 2000 plan conditions according to the water control facility standards set forth in Chapter II of this volume.*

[b] *Bridges and culverts are identified by structure number and are located on Map 41 of Volume 1 of this report.*

[c] *Overtopping is a result of backwater from Underwood Creek.*

[d] *Not available.*

Source: SEWRPC.

presently no crossing exists—as well as the design of replacements of or modifications to existing bridges or culverts, should be based upon the applicable objectives and standards set forth in Chapter II of this volume. Of particular importance is the standard which requires that all new or replacement bridges and culverts be designed so as to accommodate 100-year recurrence interval flood discharge under year 2000 plan conditions without raising the corresponding peak stage by more than 0.5 feet above the peak stage for the 100-year recurrence interval flood, as established in the adopted comprehensive watershed plan. This provision is intended to assure that the new, modified, or replacement river crossings, including their approaches, will not aggravate existing flood problems, create new flood hazards, or unnecessarily complicate the administration of floodland regulations.

PRIMARY NONSTRUCTURAL FLOODLAND MANAGEMENT MEASURES

Of the 10 available nonstructural floodland management measures set forth in Table 18 and discussed earlier in this chapter, three are particularly effective for minimizing aggravation of existing problems and for preventing development of future flood hazards. These three preventative measures are: reservation of floodlands for recreational and related open space uses through such measures as private use or public acquisition of the land or of an easement; floodland use regulation as accomplished through zoning, land subdivision, sanitary, and building ordinances; and regulation of land use outside of the floodlands which could also be accomplished through zoning, land subdivision, sanitary, and building ordinances.

It is apparent that these three primary nonstructural floodland management measures are directed toward regulation or some form of control over the use of land as that use may either aggravate existing flood problems or create new ones. With respect to their application to the Menomonee River watershed, the above nonstructural preventative measures are discussed below in two categories: land use controls within the floodlands and land use controls outside of the floodlands.

Land Use Control Within Floodlands

Encouragement of Recreational and Related Open Space Uses: The Menomonee River watershed land use plan element recommends, as described in Chapter III of this volume, the continued use and maintenance for outdoor recreation and related open space purposes of 7.2 square miles of existing public and private outdoor recreation and related open space lands. All of these lands lie within the primary environmental corridors of the watershed and, inasmuch as the corridors generally follow the alignment of the major stream systems, much of the existing public and private outdoor recreation and related open space land also encompasses the floodlands of the watershed. The land use plan also recommends the acquisition of 4.8 square miles of selected high value primary environmental corridor lands located primarily along the main stem of the Menomonee River, lands which also encompass floodland areas.

Assuming implementation of the land use plan, the total 12.0 square miles of primary environmental corridor land—about three-fourths of the total primary environmental corridor in the watershed—would be available in public or private ownership, for outdoor recreation and related open space uses. Maintenance of existing public or private outdoor recreation and related open space lands and reservation—by public or private ownership or by easement—of additional land for these purposes constitute an important and effective means of implementing the recommended land use plan for the watershed.

Selected portions of the primary environmental corridors, besides being an effective general means of protecting the natural resource base, also serve to protect the watershed in particular through such specific ways as the use of floodlands for outdoor recreation and other open space activities, so constituting an effective means of minimizing the aggravation of existing flood problems or the development of new flood problems. It is evident from a study of historic flood problems in the watershed, as reported in Chapter VI, Volume 1 of this report, that placement of urban development in floodland areas is the principal cause of the flood problems that currently exist in the basin. In addition, hydrologic-hydraulic simulation studies described earlier in this chapter clearly demonstrate that the substantial reduction in floodwater storage and conveyance associated with floodland fill and development may be expected to produce significant increases in downstream flood flows, stages, and areas of inundation, thereby seriously aggravating existing flood problems or creating new ones.

It is recommended, therefore, that the use of floodland areas for outdoor recreation and related open space activities be emphasized and carried out not only to implement the land use plan—particularly the primary environmental corridor plan elements which recommend continued use and maintenance of 7.2 square miles of existing public and private outdoor recreation and related open space lands and the acquisition of 4.8 square miles of selected high value corridor lands—but also to minimize the aggravation of existing flood problems and the development of new flood problems.

Floodland Regulations and the Wisconsin Floodplain Management Program: Wisconsin Statutes require that all counties, cities, and villages in the watershed with existing or potential flood hazards adopt reasonable and effective floodland regulations in accordance with the floodplain management program administered by the Wisconsin Department of Natural Resources. As discussed in Chapter III of this volume, floodland or floodland-related regulations such as wetland or conservancy zoning have been adopted by four cities—Brookfield, Mequon, Milwaukee, and Wauwatosa—and by three villages—Elm Grove, Germantown, and Menomonee Falls—in the watershed.

While these floodland and floodland-related regulations do control development in flood hazard areas to various degrees, they do not generally meet the minimum requirements of the State of Wisconsin floodplain management program: The principal failing is the absence of adequate flood hazard information including the delineation of the limits of the 100-year recurrence interval floodlands. Flood hazard information suitable for floodland regulation purposes is now available for the watershed stream system as a result of the hydrologic-hydraulic analyses conducted under the Menomonee River watershed planning program.

It is recommended, therefore, that the above four cities and three villages revise their floodland and floodland-related regulations so as to be fully consistent with the flood hazard data developed under the study for year 2000 land use plan conditions. It is further recommended, based on the identification of existing or potential flood hazards under the watershed planning program, that the following three communities utilize the flood hazard data generated by the planning program in the preparation and adoption of floodland and floodland-related regulations: the City of West Allis, the Village of Butler, and the City of Greenfield.

In addition to meeting minimum hydrologic-hydraulic standards established by the State of Wisconsin floodplain management program, it is imperative that the floodland and floodland-related regulations developed for the Menomonee River watershed be explicitly designed to complement and to help to implement the recommended land use plan. This is particularly important for the primary environmental corridor element of that plan which recommends the protection of 16.3 square miles of primary environmental corridor by a combination of four measures: maintenance of 7.2 square miles of existing public and private outdoor recreation and related open space lands; acquisition of 4.8 square miles of selected high value primary environmental corridor lands; application of woodland-wetland and wildlife habitat management techniques to all corridor lands; and use of land use controls to protect those 4.3 square miles of primary environmental corridor lands not in public or private outdoor recreation use and not recommended for acquisition under the watershed plan.

More specifically, it is recommended that in order to conserve the floodwater storage and conveyance capacity of the natural floodlands, in order to abate future flood hazards and monetary flood damages, in order to reduce the existing hazards to human health and safety caused by unwise occupation of floodlands, in order to reduce the expenditure of public funds to secure the health and safety of floodland residents during periods of flooding, and in order to promote sound land use development and natural resource base protection, one of two basic types of floodland and floodland-related measures should be instituted by the local units of government on a reach-by-reach basis in the watershed. These two recommended measures are:

1. In those areas of the floodlands lying within the 100-year recurrence interval flood hazard lines under year 2000 plan conditions that are presently neither developed for urban use nor committed to such development by the recordation of land subdivision plats and installation of municipal improvements such as street pavements and sewer and water utility lines, all future incompatible urban development be discouraged through appropriate floodland and floodland-related land use regulations.

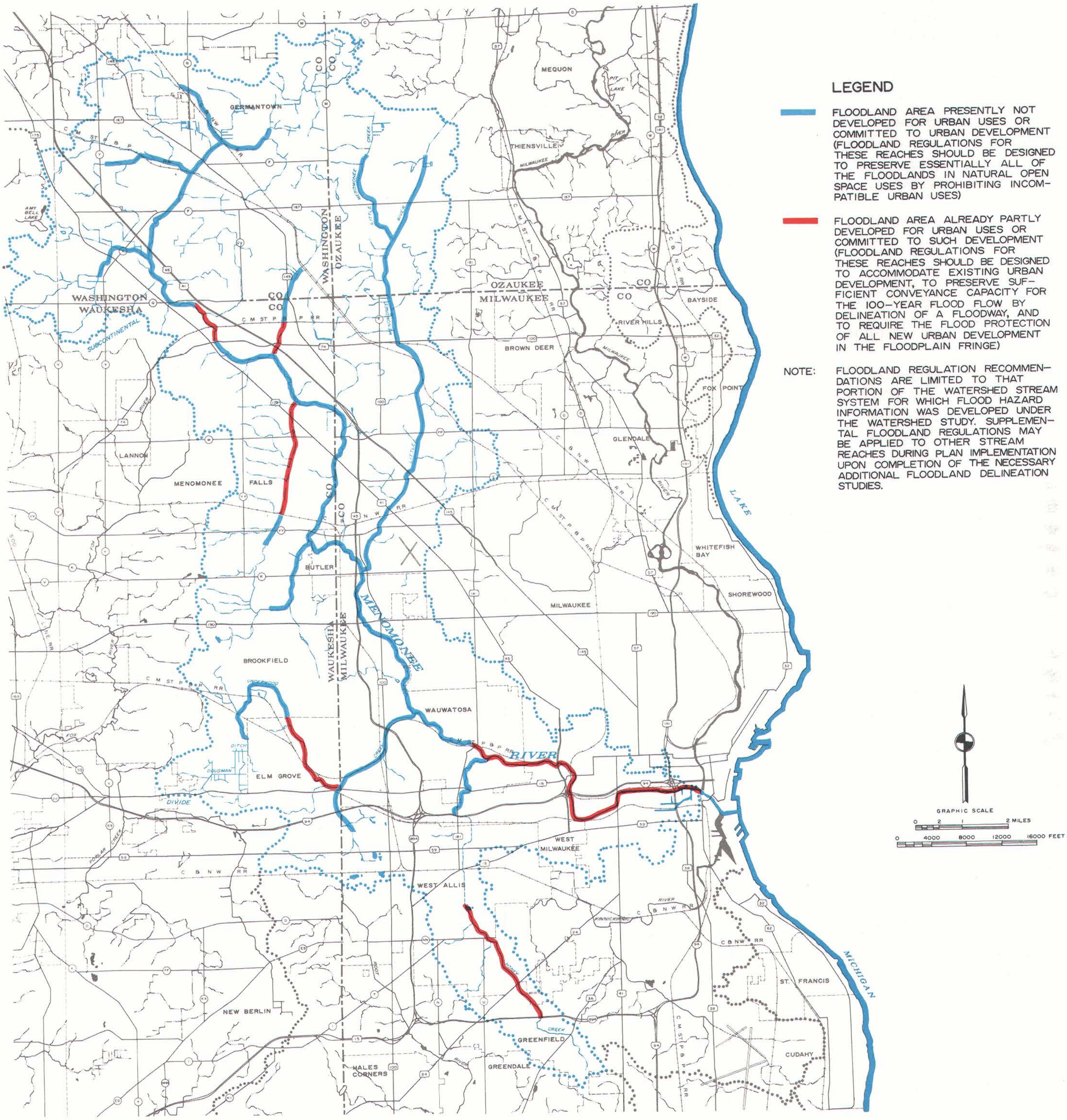
2. In those areas of the floodlands that are already completely or partly developed for urban uses, or committed to such development, the floodland and floodland-related land use regulations should be designed so as to accommodate existing development, to preserve sufficient conveyance capacity for the 100-year floodflow through delineation and preservation in open use of a floodway, and to require the floodproofing of all new urban development permitted in the floodplain fringe.

Map 42 shows the manner in which the above two types of floodland regulations are proposed to be applied to the watershed stream system. This reach-by-reach identification of the recommended approach to floodland regulations is intended to identify those portions of the watershed in which floodland regulations should be designed to preserve in essentially open, natural conditions all of the floodland areas, as opposed to those portions of the watershed in which floodland regulations must reflect the reality of existing urban development. Flood stage and channel bottom profiles and corresponding small scale flood hazard maps for 72 miles of stream system in the watershed are attached as Appendix D. In addition an index map showing the availability of large scale flood hazard maps is attached as Appendix F. Of the approximately 72 miles of watershed stream system for which the preparation and adoption of floodland regulations are recommended in the watershed plan, about 56 miles would be subjected to regulations intended to preserve in essentially natural, open use all of the 100-year floodlands under year 2000 conditions. The remaining 16 miles would be subjected to regulations intended to recognize the commitment to urban development that already exists while preserving a sufficient floodway area to provide for the safe conveyance of the 100-year recurrence interval flood flow.

While the above floodland regulation recommendations are intended to have a positive long-range effect, they are based on existing riverine area land use and, because of the rapid urbanization process occurring within the watershed, are intended for immediate implementation including implementation in those reaches for which structural flood control works are recommended. It is likely that the eventual implementation of recommended structural flood control works, such as major channel modifications and a detention reservoir, will necessitate the eventual adjustment of floodland regulations within and immediately downstream of channelized reaches and immediately downstream of the detention reservoir. For example, construction of the recommended Dousman Ditch detention reservoir in the City of Brookfield will reduce the lateral extent of the floodplain downstream along Dousman Ditch and Underwood Creek in the City of Brookfield and Village of Elm Grove. Construction of major

Map 42

FLOODLAND REGULATION RECOMMENDATIONS FOR THE MENOMONEE RIVER WATERSHED



In order to avoid intensification of existing flood problems and the creation of new flood problems, two types of local floodland regulations are proposed to be applied in the riverine areas of the watershed. Riverine reaches containing floodland areas that are presently neither in urban use nor committed to such use should be regulated so as to prevent all future incompatible urban development within the 100-year recurrence interval flood hazard lines. Such regulations will preserve the floodwater storage and conveyance capacity of the floodland area as well as avoid the construction of new flood damage prone structures. In those river reaches containing floodland areas that are partly developed for urban use, or have been committed to such use by platting, street improvement, and utility installation the floodland regulations should be designed so as to accommodate the existing development while preserving sufficient conveyance capacity to pass the 100-year floodflow through use of a floodway, and to require the floodproofing of all new structures development permitted in the floodplain fringe.

Source: SEWRPC.

channel works along the main stem of the Menomonee River in the Village of Menomonee Falls will markedly reduce the lateral extent of the floodplain. The need to eventually alter floodplain regulations is reflected in the adopted water control facility development objectives, principles, and standards for the watershed as set forth in Chapter II of this volume. The relevant standards state that the construction of structural flood control works shall be deemed to change the limits and extent of associated floodways and floodplains but that no such changes shall become effective for the purposes of land use regulations until such time as the structural flood control works are actually constructed and operative.

In summary, the overriding consideration in the preparation and adoption of floodland regulations throughout the watershed stream system is the manner in which these regulations complement the recommendations made in Chapter III of this volume concerning the protection of the primary environmental corridors. Floodland regulations can be an effective means of implementing the primary environmental corridor plan subelement recommendations, including providing interim control over corridor lands recommended for eventual acquisition, provided that the regulatory objectives are expanded beyond the single purpose of flood damage mitigation so as also to include protection of the primary environmental corridor.

Land Use Controls Outside of the Floodlands

The hydrologic-hydraulic studies conducted under the watershed planning program clearly demonstrate the probable impact on flood flows and stages of changing land use outside of the watershed floodland as well as within the floodlands. For example, complete urbanization of the watershed land surface outside of the floodlands while maintaining the floodlands in their present conditions could be expected to result, for 10 locations distributed throughout the watershed stream system, in increases in the 100-year flood flow relative to existing-conditions-100-year-flood-flows ranging from about 1.1 to 3.1. In contrast, under conditions of the year 2000 land use plan, the ratio of 100-year flood flows at the same 10 locations relative to existing conditions would vary from 1.0 to a high of 1.5.

Many factors enter into the design of land use plan for the Region and for the watershed including relating new development sensibly to soil capabilities, to long established and planned utility systems, and to the natural resource base of the watershed and the allocation of sufficient land to each of the various major land use categories. The land use plan is also a key element in floodland management plan for watershed and it should be emphasized that the recommended structural and nonstructural floodland management measures for the Menomonee River watershed assume the implementation of the year 2000 watershed land use plan. Failure to recognize the impact of land use on flood problems and accordingly to control the manner in which incremental urbanization occurs in the Menomonee River watershed could negate the positive flood mitigation aspects of many of the other nonstructural floodland management measures as well as the structural measures recommended for the basin.

SECONDARY NONSTRUCTURAL
FLOODLAND MANAGEMENT MEASURES

Of the total of 15 available floodland management measures described earlier in this chapter, all but five have been considered in the chapter as they relate to the Menomonee River watershed. The remaining measures, all of them nonstructural, are: federal flood insurance, lending institution policies, realtor policies, community utility policies, and emergency programs. The application of each of these remaining nonstructural measures to the Menomonee River watershed is discussed below. Although none of these measures alone is well suited to eliminating or significantly reducing existing flood problems, a combination of these measures properly applied to a community may be instrumental in preventing the aggravation of existing flood problems or minimizing the development of future flood hazards; may help to alleviate the monetary flood loss incurred by owners of existing flood-prone property; and, in the case of emergency measures, may substantially reduce the threat to the life and health of residents of floodprone areas.

Federal Flood Insurance

While the federal flood insurance program does not solve flood problems or mitigate flood damages, it does provide a means for distributing monetary flood losses in the form of an annual flood insurance premium and, in those situations where the insurance premiums are subsidized, the federal flood insurance program also provides a way of reducing monetary flood losses to the owner. It is, therefore, in the best interest of watershed communities to participate in the federal flood insurance program

While the ultimate decision to purchase flood insurance remains with individual property owners, initiative to establish the program within a particular community must be taken by the municipality having jurisdiction over zoning and building codes. The municipality must file a formal request with the U.S. Department of Housing and Urban Development for consideration for participation in the flood insurance program, including in its application an account of the historic flood problems in the community and a map of the community on which are delineated those flood-prone areas for which insurance is desired. Such application must also include copies of adopted floodland regulations or other adopted measures intended to prevent or reduce future flood damages. The community or unit of government must also submit assurances of future compliance, including resolutions indicating that flood problems will be continuously monitored and that such problems will be considered in all official actions affecting floodland use. Historic flood information and other flood hazard data developed under the Menomonee River watershed planning program will be useful to watershed communities seeking full participation in the federal flood insurance program.

Based on the hydrologic-hydraulic analyses conducted under the watershed study, existing or potential flood problems have been identified in the watershed portions of all watershed civil divisions with the exception of the unincorporated areas of Washington County including the

Towns of Germantown and Richfield; the unincorporated areas of Waukesha County including the Towns of Lisbon and Brookfield; the City of New Berlin in Waukesha County; and the Village of West Milwaukee and the Village of Greendale in Milwaukee County. Those communities which have clearly identified flood problems should act to participate in the federal flood insurance program. Although flood hazards have been identified in the Milwaukee County portion of the Menomonee River watershed, that entire area has been incorporated and, therefore, it is not necessary for Milwaukee County to participate in the federal flood insurance program. Some of the excepted communities—for example, the City of New Berlin—will likely participate in the program by virtue of having flood-prone areas outside of the Menomonee River watershed.

As of the end of 1975, all of the seven cities and six villages located wholly or partly in the Menomonee River watershed, as well as the unincorporated areas of the watershed in Washington and Waukesha Counties, had taken the necessary affirmative steps to become eligible to participate in the Federal flood insurance program. In response to those requests for participation under the emergency phase of the program, the U.S. Department of Housing and Urban Development has published preliminary flood hazard boundary maps for all of the above eligible civil divisions with the exception of the unincorporated areas of Washington and Waukesha Counties and the Village of West Milwaukee. In addition, the U.S. Department of Housing and Urban Development, in cooperation with the Wisconsin Department of Natural Resources which coordinates their flood insurance program within the State, has authorized insurance rate studies for the following civil divisions located wholly or partly in the Menomonee River watershed: the Cities of Greenfield, Milwaukee, and Wauwatosa in Milwaukee County and the Cities of New Berlin and Brookfield and the Villages of Menomonee Falls and Butler in Waukesha County.

It is recommended that the U.S. Department of Housing and Urban Development, in cooperation with the Wisconsin Department of Natural Resources, authorize the conduct of insurance rate studies in the following communities which have been identified as having flood hazard areas and are located wholly or partly in the watershed: the City of West Allis in Milwaukee County, the Village of Germantown in Washington County, and the Village of Elm Grove in Waukesha County. Although a flood insurance study has been completed for the City of Mequon, that study did not include the development of flood hazard data for the Menomonee River watershed portion of the City and, therefore, it is recommended that a supplemental insurance rate study be conducted for the Menomonee River watershed portion of the City of Mequon using the flood hazard data developed under the watershed study. With completion of the above seven authorized insurance rate studies and the recommended additional three insurance rate studies, property owners in all watershed communities having clearly identified flood problems will be able to participate in the regular flood insurance program.

The analysis conducted under the Menomonee River watershed planning program anticipated the eventual conduct of flood insurance rate studies and, therefore, hydrologic-hydraulic data needed to prepare those studies have been generated under the watershed planning program. In particular, these data include 10-, 50-, 100-, and 500-year recurrence interval flood stage profiles and associated floodplain delineations. It is recommended that the contractors retained by the U.S. Department of Housing and Urban Development to conduct the flood insurance rate studies make maximum utilization of the flood hazard data developed under the watershed program.

Lending Institution Policies

As a result of the National Flood Insurance Program, private lending institutions in the southeastern Wisconsin area have generally assumed the responsibility for determining whether or not a property is in a flood-prone area and, if so, they require the purchase of flood insurance before granting a mortgage for a structure on the property. It is recommended that lending institutions continue to determine the flood-prone status of properties prior to the granting of a mortgage, irrespective of the requirements of the National Flood Insurance Program, and that the principal source of flood hazard information within the Menomonee River watershed be that developed under the watershed planning program and available through either local units of government or the Regional Planning Commission.

Realtor Policies

As noted earlier in this chapter, an executive order by the Governor of Wisconsin in 1973 strongly urges that real estate brokers, salesmen, and their agents inform potential purchasers of property of any flood hazards which may exist at the site. It is strongly recommended that this program be continued inasmuch as the purchaser of property, particularly a potential buyer of a residence or of a lot for construction of a residence, is not likely to be aware of the threat to life and property posed by an event as rare as a major flood.

Community Utility Policies

As discussed earlier in this chapter, local communities may adopt policies relating to the extension of certain public utilities and facilities such as sanitary sewers, water mains, and streets in recognition of the likely influence of the location and size or capacity of such utilities and facilities on the location of new urban development. It is recommended that the policies of governmental units and agencies having responsibility for such utilities and facilities within the Menomonee River watershed be formulated so that the size, location, and use of those utilities and facilities be consistent with the flood-prone status of riverine areas. More particularly, it is recommended that these utility and facility policies be designed to complement the floodland regulation recommendations for the Menomonee River watershed and the recommended primary environmental corridor protection plan subelement.

Emergency Programs

An emergency program to minimize the damage and disruption associated with flooding normally consists of a variety of devices and techniques that are tailored to the flood hazard characteristics of individual communities. It is particularly pertinent to note that historic data and simulation results reveal that most of the urban portions of the Menomonee River watershed are classified as being hydrologically and hydraulically "flashy" in that major flood events are likely to be caused by intense rainfall events that are unpredictable as to location and time of occurrence and that there may be only several hours of elapsed time between the initial rise of floodwaters and the occurrence of peak stages. It therefore follows that it is not practicable to establish a system to predict the location, magnitude, and time of occurrence of peak flood stages. In addition, these studies indicate that peak flood discharges within the Menomonee River watershed for selected recurrence intervals may be expected to be several times larger than those that would occur in rural watersheds of similar size, soils, and topography.

It is recommended, therefore, that each watershed community develop procedures to provide floodland residents and other property owners with information about floods that are already in progress. While the optimum combination of measures comprising such an information system will differ from community to community, it is suggested that measures such as the following be considered: monitoring of National Weather Service flash flood water bulletins and flash flood warning bulletins during periods when rainfall or snowmelt are occurring or are anticipated, patrolling riverine areas to note when bankfull conditions are eminent, emergency messages broadcast to community residents over radio and television, use of police patrol cars or other vehicles equipped with public address systems, and use of warning sirens having a special pattern to indicate that flooding is occurring, especially during nighttime hours. While emergency measures like those recommended above may alleviate some damage to property in flood-prone areas by providing property owners with time to prepare for the flood stage, their most significant benefit is that they provide a way to reduce the threat to the life and health of residents of flood-prone areas, particularly during nighttime hours when residents of riverine areas may not be aware of rising flood waters. None of the other floodland management alternatives available to watershed communities is directed explicitly to the protection of the inhabitants of existing flood-prone areas.

ACCESSORY FLOODLAND MANAGEMENT CONSIDERATIONS

During the Menomonee River Watershed Planning Program there emerged several items of interest which, although not pertaining directly to floodland management alternatives as set forth in this chapter, did relate to the overall existing and potential flood problems in the Menomonee River watershed. These matters of concern were examined during the watershed planning process, and the resulting conclusions and recommendations based on that examination are described below.

Maintenance of Stream Gaging Network

When the Menomonee River Watershed Planning Program was initiated in 1972, there was one established daily stream gaging station in the basin, that being a U.S. Geological Survey wire weight gage located at the N. 70th Street crossing of the Menomonee River in the City of Wauwatosa; the wire weight gage had been in operation since October 1, 1961. As a result of the International Joint Commission (IJC) Menomonee River Pilot Watershed Study which was begun in 1974, there were, at the end of 1975, 11 continuous recording stream gaging stations housed in semipermanent structures in the Menomonee River watershed—three on intermittent streams and eight on the perennial stream system, with one of the latter group being located at the site of the wire weight gage on the Menomonee River in the City of Wauwatosa. This network of 11 continuous flow recordation gaging stations is operated by the U.S. Geological Survey as a participant in the IJC Menomonee River Pilot Watershed Study.

The U.S. Geological Survey also maintains three partial record stations in the watershed: a crest stage gage operated since 1959 at the N. 70th Street crossing of Honey Creek in the City of Milwaukee, a low flow gage operated since 1962 at the Washington-Waukesha County line on the Menomonee River, and a combination crest and low flow gage operated since 1958 at the Donges Bay Road crossing of the Little Menomonee River in the City of Mequon. Map 43 shows the location and type of stream gaging stations operated by the U.S. Geological Survey in the Menomonee River watershed as of the end of 1975.

In addition to the above stream flow monitoring stations in the watershed, a total of 29 crest stage gages are operated in the Milwaukee County portion of the basin by the Milwaukee-Metropolitan Sewerage Commissions; a total of 38 staff gages are maintained by the City of Milwaukee in the Milwaukee portion of the watershed; and a total of 14 staff gages are maintained along the Menomonee River within the Village of Menomonee Falls.

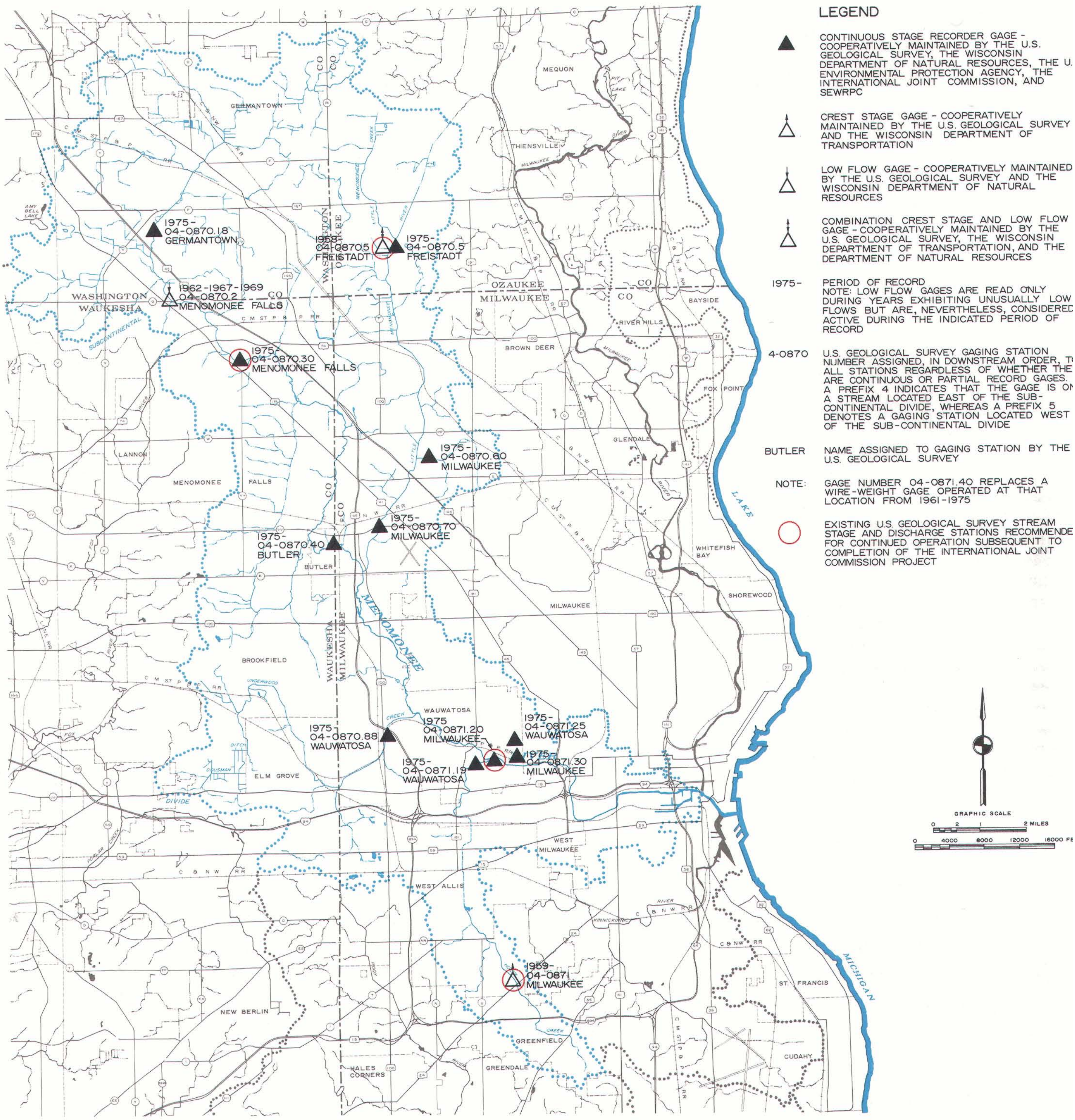
It is also important to note that, as a part of the IJC Menomonee River Pilot Watershed Study, the Wisconsin Department of Natural Resources maintains automatic water quality sampling and monitoring equipment at the 11 streamflow gaging sites established for the IJC study, as well as one additional water quality station on the Menomonee River in the industrial valley near 27th Street. Most of the water quality apparatus at each of the 12 sites is housed within the 11 semipermanent structures that house the stream gaging apparatus plus one additional such structure at the industrial valley site.

Continuous recording stream gaging stations, as well as partial record streamflow stations and crest stage stations, by monitoring river flows and stages at points strategically located within the watershed can provide critical data required for future rational management of the surface water resources of the basin for the following reasons:

1. The records from such gaging stations, particularly those stations located in the upper portions of the watershed near the present urban-rural transition zone, may eventually serve as indicators of the hydrologic and hydraulic effect of headwater urbanization. This is particularly important in the Menomonee River watershed where the headwater areas are still essentially rural in character and where simulation studies

Map 43

LOCATION OF U. S. GEOLOGICAL SURVEY STREAM GAGING STATIONS IN THE MENOMONEE RIVER WATERSHED: 1975



When the Menomonee River watershed planning program was initiated in 1972, there was one stream gaging station located in the basin, a U. S. Geological Survey wire weight gage located at the N. 70th Street crossing of the Menomonee River in the City of Wauwatosa. It had been in operation since October 1, 1961. As a result of the International Joint Commission Menomonee River Pilot Watershed Study which was initiated in 1974, there were, at the end of 1975, 11 continuous recording stream gaging stations housed in permanent structures in the Menomonee River watershed at the locations shown on this map. The U. S. Geological Survey also maintains three partial record stations in the watershed as shown on the map. The comprehensive plan for the Menomonee River watershed recommends that the continuous recorder gages installed at the N. 70th Street crossing of the Menomonee River at Wauwatosa and at the Pilgrim Road crossing of the Menomonee River in the Village of Menomonee Falls, for purposes of the IJC Menomonee River Pilot Watershed Study, continue to be operated subsequent to completion of that research project. Records from these gaging stations will serve as indicators of the hydrologic and hydraulic effect of headwater urbanization and can be used to periodically refine the hydrologic-hydraulic simulation model developed and used in the Menomonee River watershed planning program as well as in the engineering of bridges and culverts and flood control works.

Source: U. S. Geological Survey and SEWRPC.

indicate the possibility of dramatic increases in downstream discharges and stages under conditions of uncontrolled urban development.

2. Discharge-frequency relationships derived from data provided by continuous recording stream gaging stations and by partial record stations in addition to flood stage profiles from crest-stage gages can be used to periodically refine the hydrologic and hydraulic simulation submodels developed and used in the Menomonee River watershed study. It is important to note that stream gaging records, obtained in conjunction with coincident water quality monitoring data, can also be used to periodically refine the water quality simulation submodel used in the watershed study.

It is recommended that the continuous recorder gage temporarily installed at the N. 70th Street crossing of the Menomonee River in Wauwatosa for purposes of the IJC Menomonee River Pilot Watershed Study continue to be operated subsequent to the completion of that research project. A continuous flow stream gage is preferable at that location in this watershed because of the hydrologically and hydraulically flashy nature of the basin which necessitates discharge measurement made at intervals of several hours rather than the daily observations normally made at the wire weight gage. It is also important to continue data collection at the N. 70th Street crossing of the Menomonee River in order to extend the stream flow data series that began there on October 1, 1961. Finally, the N. 70th Street crossing is reasonably close to the downstream end of the Menomonee River watershed and, therefore, provides a means of monitoring the hydrologic and hydraulic behavior of this urbanizing watershed as it responds to additional urban development both within and outside of the floodland area.

It is further recommended that the continuous recorder gage installed on the Menomonee River at Pilgrim Road (CTH YY) in the Village of Menomonee Falls for purposes of the IJC Menomonee River Pilot Watershed Study be maintained after conclusion of that study as a permanent monitoring station. As indicated earlier in this chapter under the discussion of the expected behavior of the watershed under alternative land use and floodland development conditions, the reach of the Menomonee River downstream of the Washington-Waukesha County line and upstream of the confluence with the Little Menomonee River is particularly susceptible to an altered hydrologic-hydraulic regime as a result of urban development. The Pilgrim Road crossing of the Menomonee River lies within this reach and a gaging station at that location would provide a means to systematically monitor the impact of that urban development.

It is recommended that two of the three partial record stations operated in the basin by the U.S. Geological Survey—the Freistadt gage on the Little Menomonee River and the Milwaukee gage on Honey Creek—continue to be operated and that the Village of Menomonee Falls, the City of Milwaukee, and the Milwaukee-Metropolitan Sewerage Commissions continue to maintain crest stage or staff gage networks.

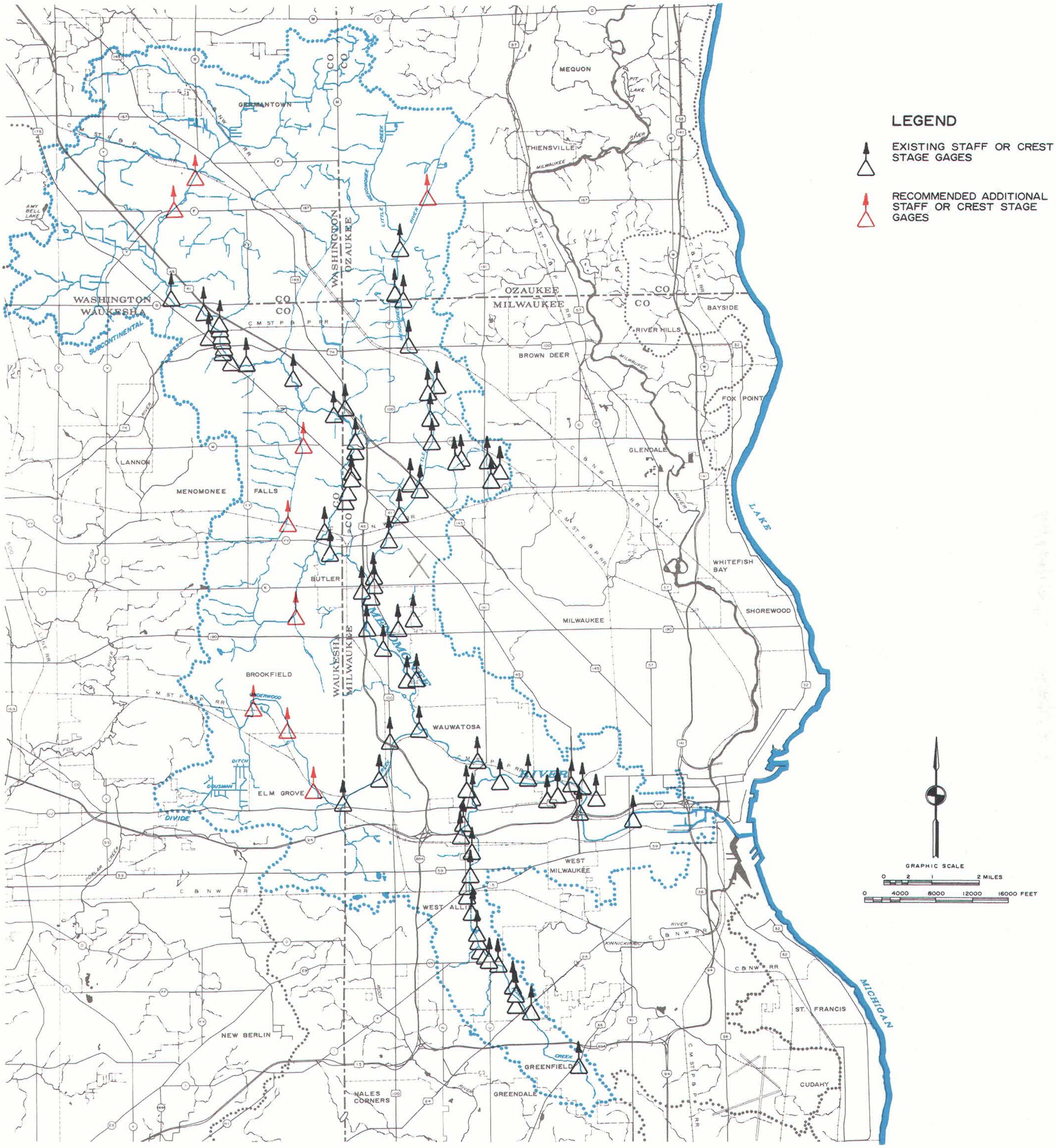
It is also recommended that certain communities located on the major stream system of the watershed establish, and in one case add to, a network of crest stage or staff gages to provide for acquisition of high water data during future major flood events. Watershed communities in which the installation of new crest or staff stage gages is recommended along stream reaches having flood problems, or in which such problems may be expected to develop in the future, include the City of Mequon in Ozaukee County, the Village of Germantown in Washington County, and the City of Brookfield and the Villages of Elm Grove and Menomonee Falls in Waukesha County. Recommended locations for the placement of a total of nine new crest or staff gages in these five communities are shown on Map 44.

The above stream gaging recommendations pertain directly to continued monitoring of flood problems in the Menomonee River watershed. It is significant to note, however, that the existence in the Menomonee River watershed of 12 semipermanent structures located throughout the basin so as to receive base flow and direct runoff from a variety of land uses and land use combinations and containing sophisticated stream flow and water quality monitoring devices offers a unique opportunity for continued hydrologic, hydraulic, and water quality research in southeastern Wisconsin. Upon completion of the International Joint Commission Menomonee River Pilot Watershed Study in early 1978, arrangements could be made by educational institutions to continue operation of some of the monitoring stations either through direct acquisition of the gaging stations and some or all of the equipment contained within them or by entering into cooperative programs with state or federal agencies such as the Wisconsin Department of Natural Resources and the U.S. Geological Survey, respectively. Such research programs might be directed to a variety of topics including the development of rainfall-runoff relationships for urban areas, the assessment of the impact of urban development on the erosion and the production of sediment, the relationship between fallout and washout from the atmosphere and the quality of surface water, the impact of street cleaning procedures in urban areas on the quality of runoff to the stream system, and the nature and rate of reaction of the watershed stream system to the planned removal of the four remaining municipal sewage treatment plants.

Most of the above suggested research programs deal primarily with the characteristics and impact of diffuse source pollution in urban and rural areas. Diffuse source pollution investigations are the principal thrust of both the IJC Menomonee River Pilot Watershed Study and the areawide water quality planning and management program for southeastern Wisconsin, both of which are underway and slated for completion by the end of 1977. It must be recognized, however, that diffuse source pollution and the problems it causes constitute a relatively new area of water resources planning and management, and it is unlikely that the current pilot watershed or the areawide water quality program will lead to a complete understanding

Map 44

RECOMMENDED ADDITIONAL CREST STAGE OR STAFF GAGES IN THE MENOMONEE RIVER WATERSHED



The present network of staff and crest stage gages in the watershed is concentrated within Milwaukee County and along the Menomonee River within the Village of Menomonee Falls. The watershed plan recommends the installation of nine additional crest stage or staff gages in the watershed at the locations shown on this map in order to provide peak flood stage data for river reaches that have experienced or may be expected to experience major flood problems in the future.

Source: SEWRPC.

of diffuse source pollution phenomena or to a complete resolution of the existing problems by the end of 1977. It is, therefore, prudent to anticipate the need for additional diffuse source pollution investigations in the southeastern Wisconsin area after completion of the IJC Menomonee Pilot Watershed Study and the planning phase of the areawide water quality management and planning program for southeastern Wisconsin. Therefore, it is recommended that local, state, and federal agencies and educational and research institutions having responsibilities in water resource and water resource-related areas in the southeastern Wisconsin area give consideration to the development of research projects, educational programs, and other special studies that could incorporate all or portions of the existing and extensive water quality-quantity monitoring network within the Menomonee River watershed.

Flood Characteristics of the Menomonee River in the Industrial Valley

For purposes of this report, the industrial valley of the Menomonee River watershed, as shown on Map 45, is defined as those low-lying industrial lands located along the Menomonee River from River Mile 0.0 at the confluence of the Menomonee and Milwaukee Rivers to River Mile 4.08 at the W. Wisconsin Avenue viaduct crossing of the Menomonee River.[11] As described in Chapter VI, Volume 1 of this report, major floods occuring in March 1897, June 1917, and March 1960 caused extensive damage and disruption in the western portions of the Menomonee River industrial valley with the Chicago, Milwaukee, St. Paul, and Pacific Railroad yard and The Falk Corporation incurring the most severe damage and disruption. Furthermore, the floods of March 1897, June 1917, and June 1940 caused extensive damage to what was then a primarily residential area located adjacent to the Menomonee River in the vicinity of what is now the W. Wisconsin Avenue viaduct.

As a result of these and other historic flood problems, structural flood control works were constructed along the Menomonee River in the portion of the Industrial Valley west of the N. 27th Street viaduct. A Works Project Administration effort completed in about 1939 resulted in deepening and widening the Menomonee River channel in the vicinity of W. Wisconsin Avenue. The Milwaukee-Metropolitan Sewerage Commissions completed further channel modifications in this area and the construction of sheet steel flood walls along the western edge of the Chicago, Milwaukee, St. Paul, and Pacific Railroad yard during the period from 1962 to 1968. Subsequent to the March 1960 flood, the Chicago, Milwaukee, St. Paul, and Pacific railroad constructed an earthen dike along the south limits of its property to provide protection against flooding. As a result of the public and private construction of the above dikes, floodwalls and channel works along the 2.10-mile-long reach of the Menomonee River extending from about N. 27th Street up to W. Wisconsin Avenue, this area did not experience any significant flood damages during the maximum flood of record—the April 21, 1973, event.

As further means of mitigating future flood damages, the Milwaukee-Metropolitan Sewerage Commissions have issued the public notice (See Figure 16) of high water problems in the industrial valley to all property owners within the area delineated in Figure 16. The notice recommends that material, facilities, and equipment located in basements within the area should be protected or so placed that water rising to an elevation of 4.0 feet above City of Milwaukee datum—equivalent to 584.6 feet above Mean Sea Level datum—will cause no damage.

In a related matter, and as discussed in Chapter III, Volume 2 of this report, the Department of City Development of the City of Milwaukee is currently involved in a major planning program designed to revitalize the Menomonee River industrial valley. Consequently, the City of Milwaukee has a renewed interest in many aspects of the industrial valley including its potential vulnerability to floods.

Because of the above three factors—the construction of dikes, floodwalls, and channel works; the establishment of recommended flood protection elevations; and the current concern with revitalization of the industrial valley—there is a particularly high interest in the flood characteristics of the Menomonee River through its industrial valley. Those characteristics are the result of the combined effect of Menomonee River flood flows and Lake Michigan stages, and any assessment of the adequacy of existing flood control works and recommended flood protection elevations requires quantification of those characteristics. Accordingly, backwater studies were conducted for the Menomonee River through its industrial valley based upon the following discharge conditions: 10-, 50-, and 100-year recurrence interval peak flood discharges under year 2000 plan conditions and the 100-year recurrence interval discharge under uncontrolled development of the floodland and nonfloodland portions of the watershed.

Historic Stages at the Menomonee-Milwaukee River Confluence: Inasmuch as the flood stages experienced in the eastern portion of the 4.08-mile-long industrial valley are influenced by Lake Michigan stages as well as by Menomonee River flood flows, the analysis of the industrial valley flood characteristics was initiated by an examination of historic stages near the Menomonee River-Milwaukee River confluence.

Based on the 74-year period of record extending from 1901 through 1974, the mean water elevation of the inner harbor at Milwaukee as determined from stage records maintained by the City of Milwaukee at the S. Water Street bridge is 579.5 feet above Mean Sea Level datum. As shown on Map 45, the bridge is located at River Mile 0.78 on the Milwaukee River, 0.1 mile downstream of the Milwaukee

[11] *The selected upstream limit of the industrial valley coincides with that used by the Milwaukee Department of City Development. See: "A Prospectus-Menomonee Valley Redevelopment Area Generic Environmental Impact Model," draft prepared by the Milwaukee Department of City Development, December 1975.*

Figure 16

NOTICE ISSUED BY MILWAUKEE-METROPOLITAN SEWERAGE COMMISSIONS RELATIVE TO BASEMENT FLOODING CAUSED BY SEWER BACKUP: MARCH 1952

GENERAL NOTICE

TO: Building Owner and/or Occupant

Record high lake levels predicted for this year may seriously interfere with the opeation of both the City and Metropolitan Sewerage Commission sewer systems by raising the levels of the rivers. This will result in direct interference with the outlets of the combined storm and sanitary sewers in the downtown area, as well as the separate sanitary sewers in other districts.

Under conditions of high lake levels, rapidly melting snow or heavy rains may result in surcharging the sewer system to a point where flooding of basements may occur.

It therefore becomes necessary for all residences, stores, commercial establishments or other buildings to protect themselves to an elevation of plus four.

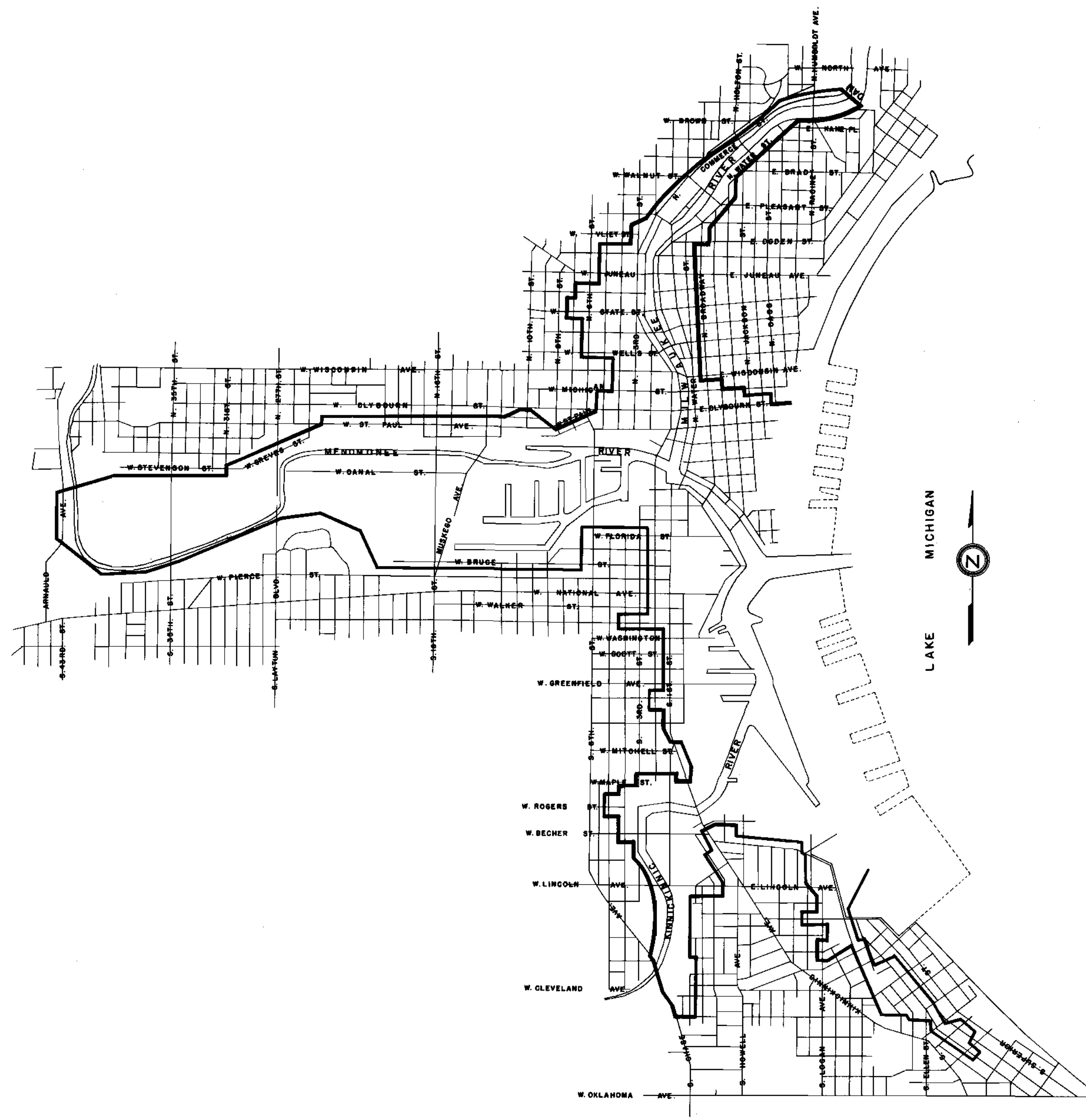
This means that materials, facilities and equipment located in basements should be protected or so placed that water rising to an elevation of four (4) feet above City of Milwaukee datum will cause no damage.

The accompanying map shows the outline of the area most likely to be affected.

CITY and METROPOLITAN SEWERAGE COMMISSIONS

March 26, 1952

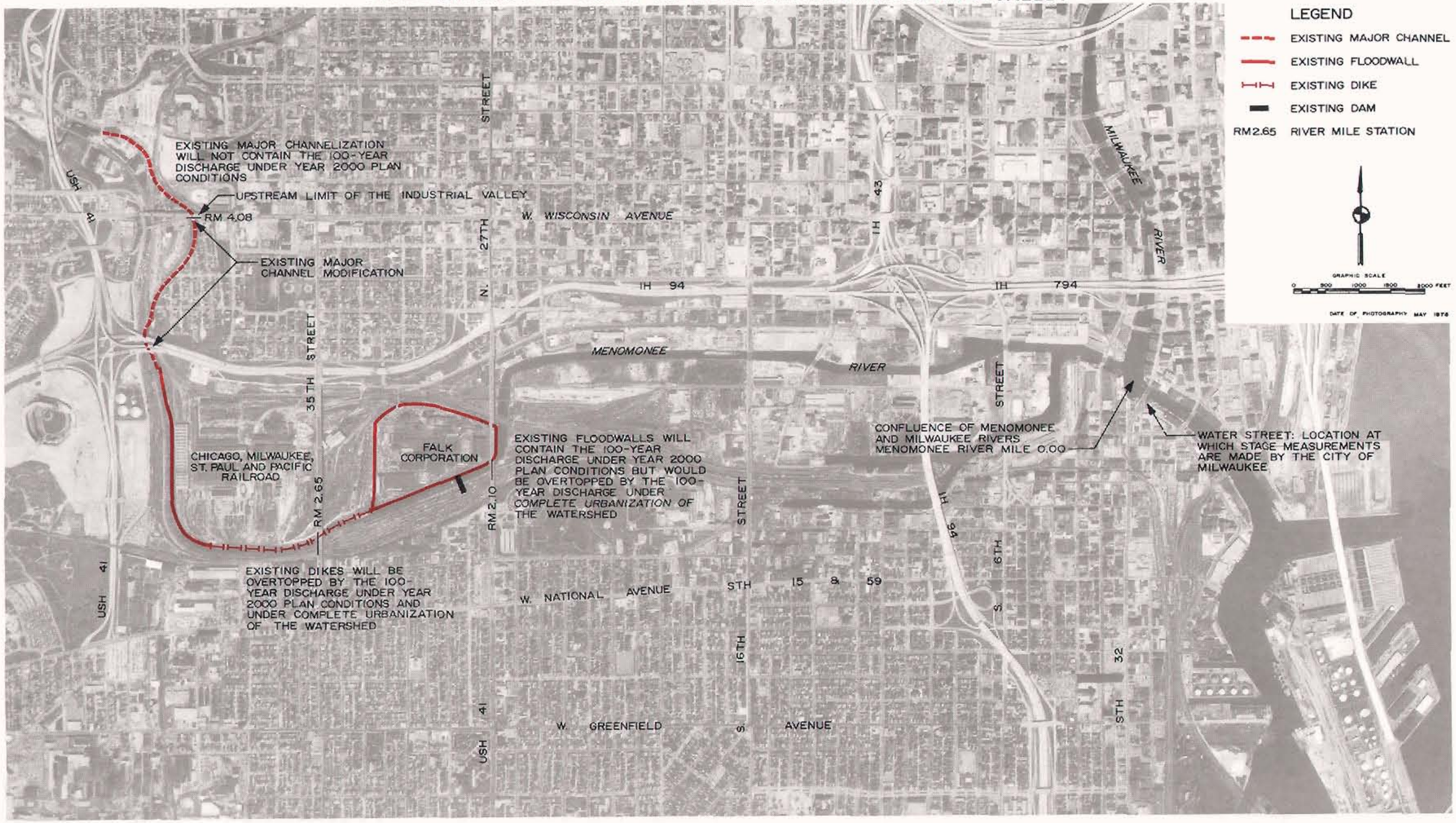
NOTE: Four feet above City of Milwaukee datum is equilent to 584.6 feet above Mean Sea Level datum.



Source: Milwaukee-Metropolitan Sewerage Commissions.

Map 45

FLOOD CHARACTERISTICS OF THE MENOMONE RIVER INDUSTRIAL VALLEY



As the result of a series of damaging flood events several major structural flood control works have been carried out in and immediately upstream of the Menomonee River industrial valley including channelization and construction of sheet steel floodwalls and earthen dikes. Analyses conducted under the watershed planning program indicate that these structural flood control works should be supplemented with miscellaneous measures such as removal of The Falk Corporation dam or with raising of the earthen dike along the southern edge of the railroad yard, and increasing the height of the floodwalls and provision of necessary backwater gates and storm water pumping stations along the east side of the Menomonee River between the East-West Freeway and W. Wisconsin Avenue viaduct; along the west side of the River between the W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge located immediately upstream; and along all or portions of both sides of the channel between the railroad bridge and N. 45th Street. These supplemental flood control works are needed to protect the industrial valley and areas immediately upstream from inundation during a 100-year recurrence interval flood event occurring under the proposed year 2000 land use and channel conditions.

Source: SEWRPC.

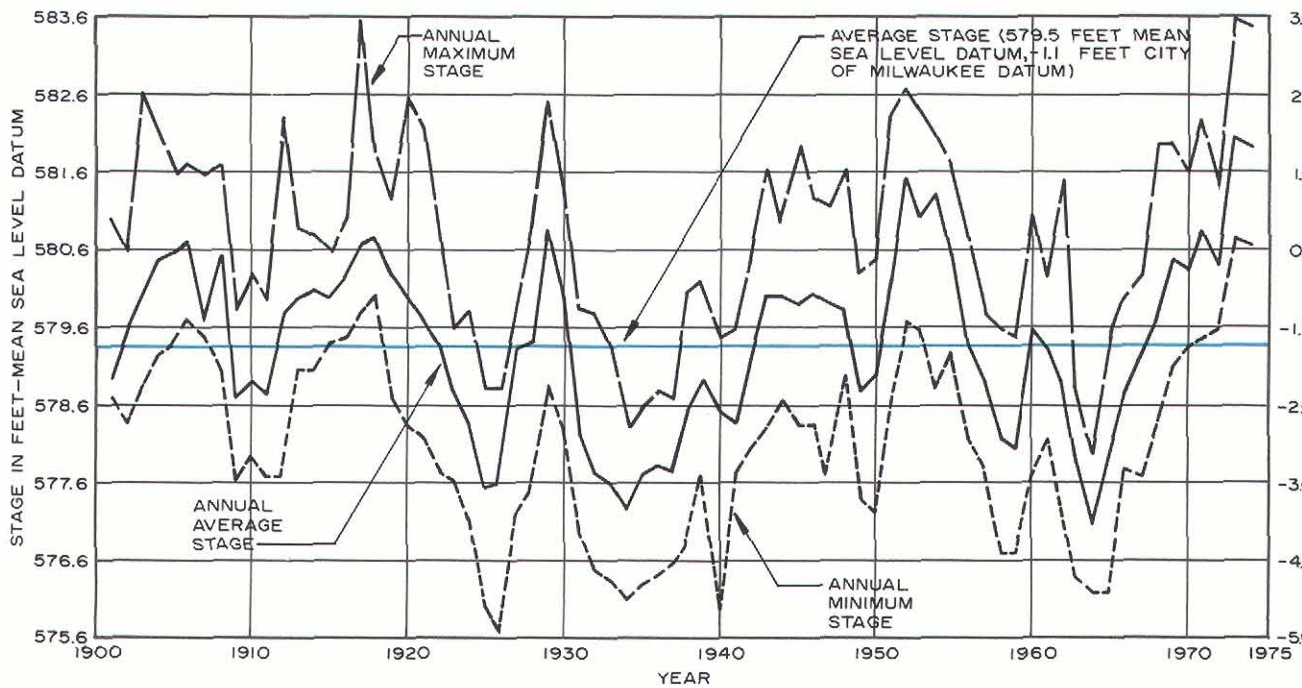
River-Menomonee River confluence. The median of the annual maximum stages of the Milwaukee River at the S. Water Street crossing and, therefore, the approximate median annual maximum stage of the Menomonee River at its confluence with the Milwaukee River, is 581.0 feet above Mean Sea Level datum, or .4 feet above City of Milwaukee datum. Stage fluctuations at this location have ranged from a low of 575.7 feet Mean Sea Level datum, 4.9 feet below City of Milwaukee datum, in 1926 to a high of 583.6 feet above Mean Sea Level datum, 3.0 feet above City of Milwaukee datum, in 1917 and again in 1973. This fluctuation in stages near the confluence of the Menomonee and Milwaukee Rivers, which approximates 8.0 feet, is illustrated in Figure 17 which shows the historic stages of the 74-year record kept by the City of Milwaukee.

The 74-year series of maximum annual stages at the Menomonee-Milwaukee River confluence were used to construct the stage-frequency relationship shown in Figure 18. This stage-frequency relationship is very similar to a stage-frequency relationship derived from 63 years of Lake Michigan stage data collected by the federal government at the U.S. Coast Guard Station in the Milwaukee Harbor. This indicates that extreme stages experienced near the confluence of the Menomonee and Milwaukee Rivers are similar to those occurring in Lake Michigan at Milwaukee. The historic stage data and the derived stage-frequency relationships provide a necessary basis for any backwater computations for the Menomonee River through the industrial valley.

Backwater Computation Procedure and Results: Historic low, median, and high maximum annual stages of 578.0, 581.0, 583.6 feet above Mean Sea Level datum at the confluence of the Menomonee and Milwaukee Rivers were used as a beginning for the backwater computations at River Mile 0.00 on the Menomonee River. These computations were extended upstream 4.08 miles to the W. Wisconsin Avenue crossing of the Menomonee River at the upper end of the industrial valley. The 100-year recurrence interval peak flood discharge under year 2000 plan conditions of 19,620 cfs was used in the computations from River Mile 0.0 to River Mile 2.49 and a discharge of 18,390 cfs was used from that point to the upstream end of the industrial valley. The 100-year recurrence interval peak flood discharge under conditions of complete watershed development of 26,500 cfs was also used from River Mile 0.0 to the upstream end of the industrial valley. In addition, backwater computations were carried out for the 10- and 50-year recurrence interval flood discharges under year 2000 plan conditions for each of the three starting stages.

Figure 17

HISTORIC STAGES AT THE WATER STREET BRIDGE ON THE MILWAUKEE RIVER: 1901-1974



NOTE:
1. THE ANNUAL AVERAGE LAKE MICHIGAN STAGE FOR 1909 WAS OBTAINED BY INTERPOLATION
2. THE WATER STREET BRIDGE IS LOCATED 0.1 MILES DOWNSTREAM OF THE MENOMONEE RIVER-MILWAUKEE RIVER CONFLUENCE

Source: City of Milwaukee Bureau of Engineering and SEWRPC.

The results of the computations are shown in Figure 19 in the form of 100-year recurrence interval flood stage profiles under year 2000 plan conditions and under uncontrolled development conditions. Table 34 summarizes the results of the computations for that portion of the industrial valley located downstream of River Mile 1.5 and shows the interrelationships between flood flows under year 2000 plan conditions, starting stages at the Menomonee-Milwaukee Rivers confluence, and Menomonee River flood stages.

Interpretation of the Results: The following observations may be made and conclusions may be drawn based on the flood stage profiles shown in Figure 19 and the supplementary flood flow-starting stage-river stage data set forth in Table 34.

1. The Menomonee River within the industrial valley may be divided into an upper and a lower reach with respect to the factors that influence flood stage profiles. Throughout the lower 1.75-mile-long reach of the Menomonee River—approximately that portion of the River east of the N. 27th Street viaduct—the flood stages are determined primarily by Lake Michigan stages, with Menomonee River flood flows exerting a secondary effect.[12] In the approximately 2.33-mile-long upper reach of the Menomonee River in the industrial valley upstream of River Mile 1.75, flood stage profiles are not influenced by stages at the Menomonee-Milwaukee confluence but are solely a function of Menomonee River flood discharges and the hydraulic characteristics of the reach, particularly the complex of four railroad bridges located between River Mile 1.87 and 1.97. These railroad structures form hydraulic obstructions that essentially determine the flood stages for the Menomonee River immediately upstream of the railroad bridges.

2. Concerning the lower reach of the Menomonee River in the industrial valley east of River Mile 1.75, Table 34 indicates that flood stages at the western end of this reach may be up to 2.0 feet higher than at the eastern end. For a given Menomonee River-Milwaukee River stage, the increase in river stage along this lower portion of the Menomonee River increases with the magnitude of the Menomonee River flood flow. For example, for a median starting stage at the Menomonee River-Milwaukee River confluence of 581.0 feet Mean Sea Level, the increment in stage along the downstream 1.5 miles of the Menomonee River is 0.5 feet, 1.1 feet, 1.5 feet, respectively, for 10-year, 50-year, and 100-year discharges under year 2000 plan conditions. For a given flood event the flood stage increment along the lower 1.5 miles of the Menomonee River increases with a decreasing Menomonee River-Milwaukee River confluence stage. For example, for a 50-year recurrence interval discharge of 16,450 cfs under year 2000 plan conditions, the stage increment along the downstream 1.5 miles of the Menomonee River associated with a high starting stage is 0.9 feet while that for a low starting stage is 1.5 feet.

3. Analyses indicate that the 100-year recurrence interval flood stage along the 1.75-mile-long reach of the Menomonee River east of approximately the N. 27th Street viaduct should generally not overtop the bulkhead walls and channel banks immediately adjacent to the River and should not, therefore, cause widespread inundation of the valley floor. There is, however, the possibility that localized surface flooding or ponding could occur either as a result of scattered overtopping of low portions of the bulkhead walls or channel banks or as a result of the backup of floodwaters through storm sewers that discharge to the Menomonee River. A precise delineation of areas that may be subject to localized flooding could not be made under the watershed planning program because of the lack of large-scale topographic maps for the industrial valley.

4. For the lower reach of the Menomonee River east of River Mile 1.75, the flood stage profiles indicate that a combination of the historic high Menomonee River-Milwaukee River confluence starting stage of 583.6 feet Mean sea Level and a 100-year Menomonee River discharge under year 2000 plan conditions of 19,620 cfs would produce, for the approximately 1.3-mile-long reach of the river from River Mile 0.45 to River Mile 1.75, a stage slightly above—by several tenths of a foot—the flood protection stage of 584.6 feet above Mean Sea Level datum, 4.0 feet above City of Milwaukee datum. The probability of the simultaneous occurrence of such a high starting stage at the Menomonee River-Milwaukee River confluence and a 100-year recurrence interval flood discharge on the Menomonee River is very

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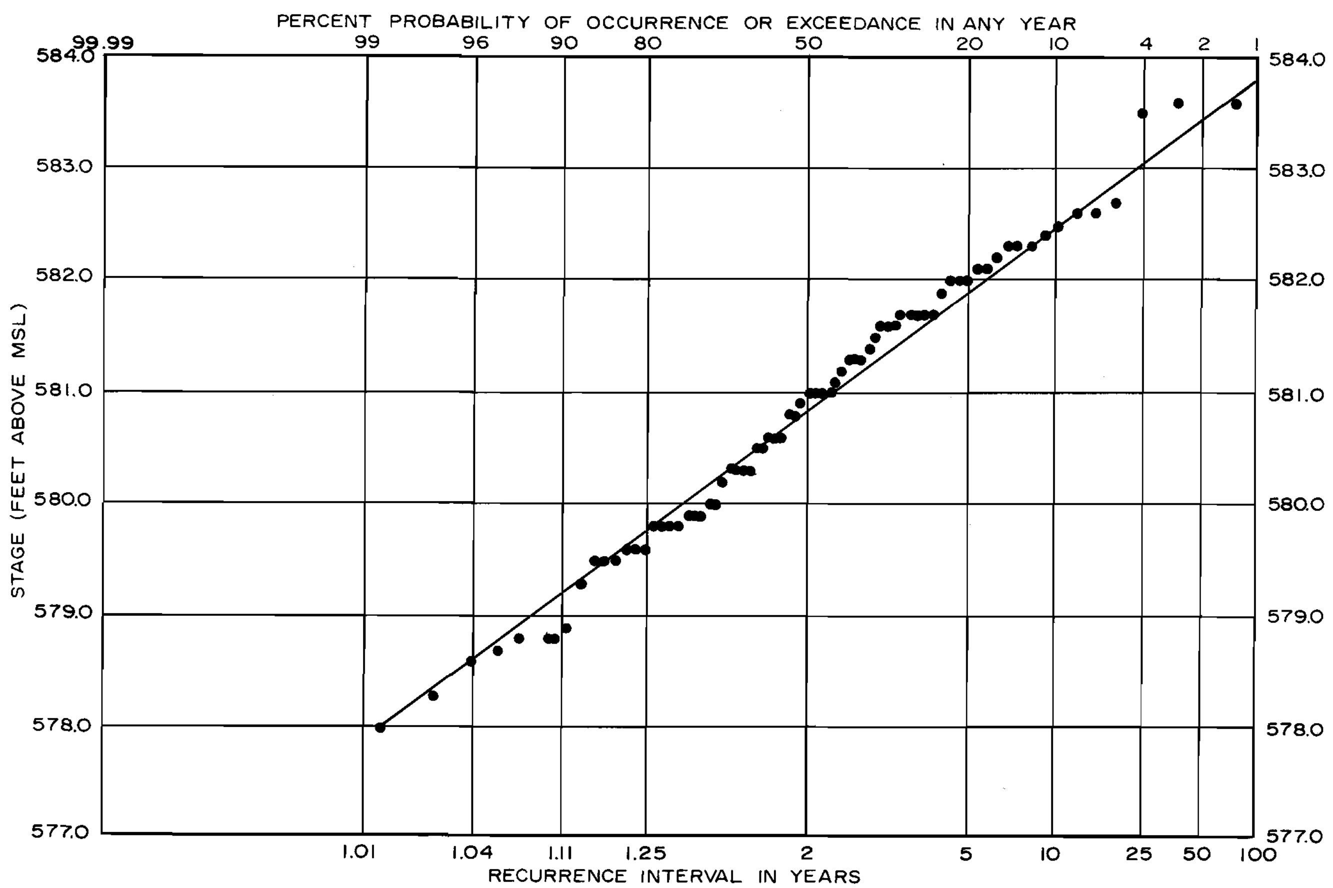
[12]*An analysis of the effect of river flood flows and Lake Michigan stages on river flood stages was carried out for the lower Milwaukee River under the SEWRPC Milwaukee River watershed planning program. The high starting stage used in conjunction with a Milwaukee River 100-year discharge under year 1990 plan conditions was 583.0 feet Mean Sea Level datum which is close to the 583.6 feet historic high starting stage used in the Menomonee River analysis. Under these conditions, the lower 3.10 mile reach of the Milwaukee River, which is bounded on its upstream end by the North Avenue dam, exhibited an approximately three foot increase in stage, or about one foot per mile. The slope of the Milwaukee River flood stage profile is identical to that which may be expected on the Menomonee River east of the 27th Street viaduct under conditions of a high starting stage and year 2000 plan-100 year recurrence interval flood flow discharge. Therefore, the lower Menomonee and Milwaukee Rivers exhibit similar behavior under conditions of high Lake Michigan levels and high flood discharges.*

small. For example, Figure 18 indicates that the probability of a starting stage at the Menomonee River-Milwaukee River confluence of 583.6 feet Mean Sea Level or higher in any year is 0.013. The probability of a 100-year recurrence interval or larger discharge occurring on the Menomonee River during that year is 0.01. Assuming that the two events are independent, their joint probability—probability that they will occur in the same year—is the product of the individual probabilities, or 0.00013 which corresponds to a recurrence interval of about 7,500 years. Furthermore, this is the probability that the combination of the high Menomonee River-Milwaukee River confluence stage and 100-year Menomonee River flood flow would occur in the same year. The probability of the two events occurring at the same time in that year is even less. While there are other combinations of starting stage at the Menomonee River-Milwaukee River confluence and the Menomonee River flood flows that could produce Menomonee River stages above the flood protection elevation recommended by the Milwaukee-Metropolitan Sewerage Commissions, the probability that any one of those would occur in a given year is very small and therefore the recommended flood protection elevation of 584.6 feet above Mean Sea Level datum may be considered adequate for the Menomonee River reach downstream of River Mile 1.75.

5. For the 2.33 mile reach of the Menomonee River industrial valley upstream of River Mile 1.75, the average slope of the 100-year recurrence interval flood stage profile under year 2000 plan conditions is steep compared to the profile downstream of River Mile 1.75—about six feet per mile for the former, versus approximately one foot per mile for the latter—with the 100-year stage for the upper portion of the valley being above the flood protection elevation of 584.6 feet Mean Sea Level as recommended by the Milwaukee-Metropolitan Sewerage Commissions

Figure 18

STAGE-FREQUENCY RELATIONSHIP BASED ON STAGES RECORDED AT THE WATER STREET BRIDGE ON THE MILWAUKEE RIVER

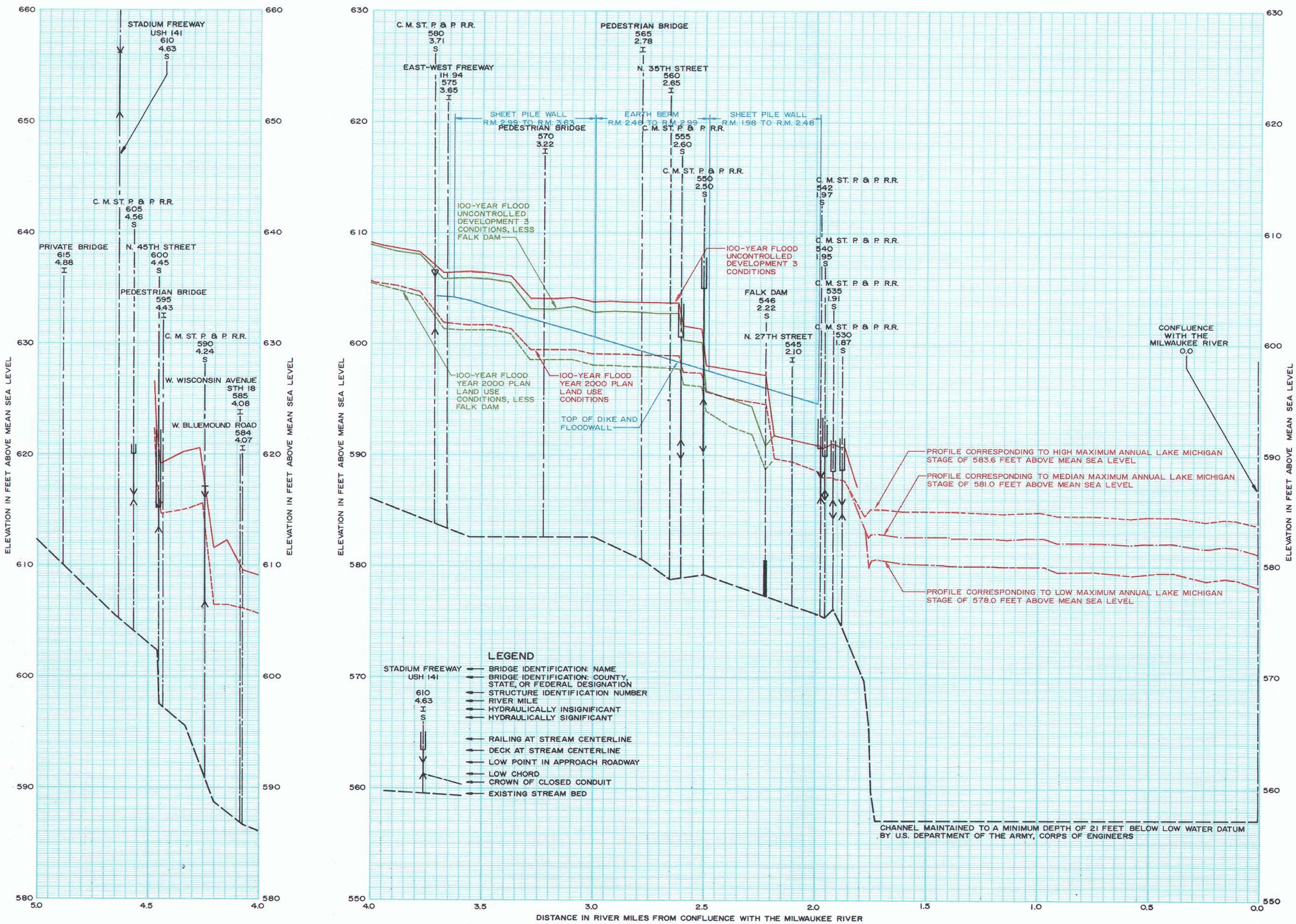


NOTE: THE WATER STREET BRIDGE IS LOCATED 0.1 MILE DOWNSTREAM OF THE MENOMONEE RIVER-MILWAUKEE RIVER CONFLUENCE

Source: SEWRPC.

Figure 19

FLOOD STAGE PROFILES FOR THE MENOMONEE RIVER IN THE INDUSTRIAL VALLEY UNDER YEAR 2000 PLAN CONDITIONS AND UNDER UNCONTROLLED DEVELOPMENT CONDITIONS



Source: SEWRPC.

Table 34

THE EFFECT OF FLOOD FLOW AND LAKE STAGE ON THE MENOMONEE RIVER DOWNSTREAM OF RIVER MILE 1.75 UNDER YEAR 2000 PLAN CONDITIONS

At River Mile 1.50

Menomonee River-Milwaukee River Confluence (feet-msl)		10-Year Recurrence Interval			50-Year Recurrence Interval			100-Year Recurrence Interval		
		Discharge (cfs)	Menomonee River Stage (feet-msl)	Stage Increase Relative to Menomonee River-Milwaukee River Confluence (feet)	Discharge (cfs)	Menomonee River Stage (feet-msl)	Stage Increase Relative to Menomonee River-Milwaukee River Confluence (feet)	Discharge (cfs)	Menomonee River Stage (feet-msl)	Stage Increase Relative to Menomonee River-Milwaukee River Confluence (feet)
High[a]	583.6	10,920	584.0	0.4	16,450	584.5	0.9	19,620	584.8	1.2
Median[a]	581.0	10,920	581.5	0.5	16,450	582.1	1.1	19,620	582.5	1.5
Low[a]	578.0	10,920	578.7	0.7	16,450	579.5	1.5	19,620	580.0	2.0

At River Mile 0.75

Menomonee River-Milwaukee River Confluence (feet-msl)		10-Year Recurrence Interval			50-Year Recurrence Interval			100-Year Recurrence Interval		
		Discharge (cfs)	Menomonee River Stage (feet-msl)	Stage Increase Relative to Menomonee River-Milwaukee River Confluence (feet)	Discharge (cfs)	Menomonee River Stage (feet-msl)	Stage Increase Relative to Menomonee River-Milwaukee River Confluence (feet)	Discharge (cfs)	Menomonee River Stage (feet-msl)	Stage Increase Relative to Menomonee River-Milwaukee River Confluence (feet)
High[a]	583.6	10,920	583.8	0.2	16,450	584.1	0.5	19,620	584.4	0.8
Median[a]	581.0	10,920	581.3	0.3	16,450	581.7	0.7	19,620	582.0	1.0
Low[a]	578.0	10,920	578.4	0.4	16,450	578.9	0.9	19,620	579.3	1.3

[a] *Based on 74 years of maximum annual stage observations by the City of Milwaukee at the Water Street Bridge (River Mile 0.78) on the Milwaukee River—0.1 mile downstream of the Menomonee River-Milwaukee River confluence.*

Source: SEWRPC.

throughout the entire reach. Along this reach of the Menomonee River, that is, upstream of River Mile 1.75, flood protection elevations at least two feet above the 100-year flood stage profile for year 2000 plan conditions should be established to supersede those established earlier by the Sewerage Commissions.

6. The 0.50-mile-long—River Mile 1.98 to 2.48—sheet pile floodwall constructed on the north side of the Menomonee River to protect The Falk Corporation complex is of sufficient height to contain the 100-year recurrence interval discharge of the Menomonee River under year 2000 plan conditions with a minimum of freeboard of about two feet. Under uncontrolled development conditions, however, the wall could be expected to be breached by floodwaters.

7. The 0.49-mile-long—River Mile 2.48 to 2.99—earthen dike constructed along the north side of the Menomonee River to protect the Chicago, Milwaukee, St. Paul, and Pacific Railroad against flooding may be expected to be overtopped near its downstream end during a 100-year flood flow discharge under year 2000 plan conditions. Under uncontrolled development condition flood flows, the entire 0.49-mile-long segment of earthen dike may be expected to be overtopped during a 100-year flood event.

8. The 0.64-mile-long—River Mile 2.99 to 3.63—sheet pile floodwall constructed on the east side of the Menomonee River to protect the Chicago, Milwaukee, St. Paul, and Pacific Railroad is of sufficient height to contain the 100-year flow of the Menomonee River under year 2000 plan conditions with a minimum freeboard of about two feet. Under uncontrolled development conditions, however, the entire length of the sheet pile floodwall may be expected to be breached by floodwaters during a 100-year recurrence interval event.

9. A portion of the 0.43-mile-long segment of channel modifications between IH 94 (River Mile 3.65) and the W. Wisconsin Avenue viaduct (River Mile 4.08) does not have sufficient capacity to contain the 100-year recurrence interval flood flow of the Menomonee River under year 2000 plan conditions. The flood stage profiles indicate that a 0.24 mile length of overbank on the east side of the channel within this reach extending from the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 3.71 to River Mile 3.95 is likely to be overtopped under year 2000 plan 100-year recurrence interval discharge conditions. The entire east bank could be expected to be breached by floodwaters with the 100-year flood flow occurring under uncon-

trolled development conditions. An approximately 23 acre area of residential development on the east side of the channelized reach may be expected to incur flood damage if the channel were overtopped. Although flooding in this residential area would be a very rare event since an approximately 50- to 75-year discharge under year 2000 plan conditions would be needed to breach the east bank, the resulting damage and disruption could be significant because of the high density of residential structures in the area that would be inundated. The topography on the west side of this reach is higher than that on the east side and, therefore, the 100-year recurrence interval peak flood discharges under year 2000 plan conditions and under uncontrolled development conditions should not affect the commercial uses on the west bank.

10. If the lowhead dam located at River Mile 2.22 and maintained by The Falk Corporation were removed, the 100-year recurrence interval flood stage profile under year 2000 plan conditions would be lowered so that the existing steel floodwalls and earthen dikes could be expected to contain the 100-year recurrence interval-year 2000 plan flood discharge throughout the 1.49-mile-long reach of the Menomonee River in the industrial valley extending from the dam upstream to the Chicago, Milwaukee, St. Paul, and Pacific Railroad at River Mile 3.71 with a minimum freeboard of about one foot. However, even if the sheet pile dam were removed, uncontrolled development conditions would produce a 100-year recurrence interval discharge and corresponding flood stage profile that could be expected to overtop the earthen dike and steel floodwalls currently protecting the Chicago, Milwaukee, St. Paul, and Pacific Railroad yard. Removal of The Falk Corporation dam would not alleviate the problem associated with the 0.43 mile channelized reach between IH 94 and the Wisconsin Avenue viaduct. Flood stage reductions in that reach attributable to removal of the dam are small, generally less than 0.5 feet. Therefore, even if The Falk Corporation dam were removed, the residential area on the east bank of the Menomonee River would be expected to be subjected to flooding during the most severe events.

Concluding Statement: Based on the analysis conducted on the flood stage profiles developed for the industrial valley under a variety of Lake Michigan stages, river flood flows, and land use development conditions, the following conclusions may be drawn concerning the existing and future flood problems in the industrial valley:

1. The flood protection elevation of 584.6 feet above Mean Sea Level datum—4.0 feet above City of Milwaukee datum—as established by the Milwaukee-Metropolitan Sewerage Commissions can continue to be applied to that reach of the Menomonee River downstream of River Mile 1.75 located at about the 27th Street viaduct.

2. A new flood protection elevation of at least two feet above the 100-year recurrence interval peak flood stage profile for year 2000 plan conditions should be established along the Menomonee River in the industrial valley upstream from River Mile 1.75, located at about the 27th Street viaduct, to supersede the flood protection elevation of 584.6 feet Mean Sea Level datum presently established by the Sewerage Commissions.

3. The earthen dike protecting the south limits of the Chicago, Milwaukee, St. Paul, and Pacific Railroad yard is of insufficient height to contain the 100-year flood under year 2000 plan conditions assuming that The Falk Corporation dam, which is located on the Menomonee River immediately downstream of the railroad yard, remains in place. Removal of The Falk Corporation dam would reduce stages so that the 100-year discharge under year 2000 plan conditions would be conveyed past the Chicago, Milwaukee, St. Paul, and Pacific Railroad property without overtopping the earthen dike. In the event that The Falk Corporation dam is continued to be required for cooling water purposes and therefore cannot be removed, the crest of the earthen dike protecting the railroad should be raised to an elevation two feet above the flood stage profile corresponding to the design discharge—the 100-year recurrence interval flow under year 2000 plan conditions.[13]

4. The east bank of the channelized reach of the Menomonee River between the North-South Freeway (IH 94) and the W. Wisconsin Avenue viaduct will not contain the selected design flow—the 100-year recurrence interval discharge under year 2000 plan conditions. Presumably, following sound engineering practice, the major channelization alternative was selected for this reach based on economic analyses and was designed to convey the 100-year recurrence interval discharge. Inasmuch as the channel will not safely convey the refined 100-year flood flow as developed under the

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[13] *A preliminary engineering study completed in 1964 proposed the "ultimate improvement" of the Menomonee River in the industrial valley upstream of N. 25th Street extended. Subsequent channel work was carried downstream only as far as River Mile 3.0 at about N. 41st Street extended and the invert of the channel bottom was not placed as low as originally proposed. Backwater computations carried out under the watershed study indicate that if the channel modifications had been constructed at the lower grade as originally proposed and if the channel modifications had been extended downstream to The Falk Corporation dam at River Mile 2.22, the 100 year flood stage profile under year 2000 planned land use conditions would not overtop the earthen dike protecting the Chicago, Milwaukee, St. Paul, and Pacific Railroad Property. (Reference: "Report on Menomonee River Flood Survey—N. 25th Street to W. Harwood Avenue," Klug and Smith Company, June 1964, 64 pp.)*

Menomonee River watershed planning program for year 2000 plan conditions, it is prudent to supplement the channel works—which represent a major expenditure of public funds—with construction of a floodwall on the east bank of this reach and with installation of necessary backwater gates and storm water pumping stations near the end of storm sewer outfalls.[14]

Adequacy of Channel Works Immediately Upstream of the Industrial Valley

Subsequent to completion of the analyses described above, which indicated that a 0.24 mile length of bank on the east side of the Menomonee River between the East-West Freeway (IH 94) and the W. Wisconsin Avenue viaduct could be expected to be overtopped under year 2000 plan and 100-year recurrence interval peak flood discharge conditions, a similar analysis was conducted for the existing major channel works located immediately upstream of W. Wisconsin Avenue. As shown on Map 44 this channelized reach of the Menomonee River extends 0.37 mile, from the W. Wisconsin Avenue viaduct at River Mile 4.08 upstream to N. 45th Street at River Mile 4.45 where a 6.0 foot channel drop marks the upstream terminus of the major channel works on the lower Menomonee River. This reach, like the reach immediately downstream, was deepened and widened as a Works Progress Administration project completed in about 1939 and was subsequently further deepened by the Milwaukee-Metropolitan Sewerage Commissions.

Analytic Procedure and Interpretation of Results: The backwater computations previously carried out for that reach of the Menomonee River from its confluence with the Milwaukee River upstream to the W. Wisconsin Avenue viaduct were extended upstream to N. 45th Street. A 100-year recurrence interval discharge under year 2000 plan conditions of 16,770 cfs was used in the analysis of the reach from the W. Wisconsin Avenue viaduct upstream to N. 45th Street. In addition, the adequacy of the channel improvements under a 100-year recurrence interval peak flood discharge of 25,100 cfs under uncontrolled development conditions was also analyzed. The analyses produced the flood stage profiles shown in Figure 19 and indicated the following:

1. The 0.16-mile-long segment of channel modifications between the W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 4.24 does not have sufficient capacity to contain the 100-year recurrence interval flood flow of the Menomonee River under year 2000 plan conditions. The flood stage profiles indicate that the entire 0.16 mile length of bank on the west side of the channel within this reach could be expected to be overtopped under year 2000 plan land use and 100-year recurrence interval peak flood discharge conditions. An approximately one acre area of residential and commercial development located along the west side of the channelized reach could be expected to incur flood damage if the channel were overtopped. Flooding in this area would be a relatively rare event since an approximately 75- to 100-year recurrence interval discharge under the year 2000 plan conditions would be needed to breach the west bank. The topography on the east side of this reach is markedly higher than that on the west side and, therefore, the 100-year recurrence interval peak discharges under year 2000 plan conditions and under uncontrolled development conditions should not affect the commercial uses located along the east bank of the River.

2. Most of the 0.21-mile-long segment of channel modification between the Chicago, Milwaukee, St. Paul, and Pacific Railroad, River Mile 4.24, and N. 45th Street, River Mile 4.45, does not have sufficient capacity to contain the 100-year recurrence interval peak flood flow of the Menomonee River under year 2000 plan conditions. The flood stage profiles indicate that all of the bank on the south side of the channel within this reach could be expected to be overtopped under year 2000 plan 100-year recurrence interval discharge conditions. An approximately 13 acre area of commercial development located on this side of the River could be expected to incur flood damage if the channel were overtopped. Although

[14] *The design of the channel works constructed between the East-West Freeway and N. 45th Street is based on a preliminary engineering study completed in 1964. This study concluded that the "maximum probable flood flow" under then existing (1964) land use and channel conditions would be about 10,000 cfs and that the 100 year recurrence interval flood flow under "ultimate" development conditions would be about 16,000 cfs. This may be compared to Menomonee River Watershed Study 100-year recurrence interval peak flood discharge under existing land use and channel conditions in this reach of 16,000 cfs, under year 2000 plan conditions of 16,770 cfs, and under complete urbanization of 25,100 cfs. The channel improvements subsequently designed and constructed along the 0.80-mile-long Menomonee River reach between the East-West Freeway and N. 45th Street and downstream of that reach to about River Mile 3.0 were sized so as to contain the existing condition maximum flood flow of 10,000 cfs. While the proposed works in this reach were designed to contain the 10,000 cfs flow, the design indicates that they would be overtopped immediately upstream of the East-West Freeway under the "ultimate" development condition 100-year flood flow of 16,000 cfs and that peak flood stages would be within about 0.5 foot of overtopping the channel sidewalls at several locations within the East-West Freeway to N. 45th Street reach. It follows, therefore, that the watershed study conclusion that the existing channel improvements between the East-West Freeway and N. 45th Street would be inadequate under year 2000-100 year recurrence interval discharge of 16,770 cfs is consistent with the results of the design of those channel works. (Reference: Ibid.)*

flooding in this commercial area would be a relatively rare event since an approximately 25- to 50-year discharge under the year 2000 plan conditions would be needed to breach the southwest bank, the resulting damage and disruption could be significant because of the industrial activity in this area.

The flood stage profiles indicate that a 0.14 mile length of bank on the north side of the channel within this reach extending from the Chicago, Milwaukee, St. Paul, and Pacific Railroad at River Mile 4.24 to River Mile 4.38 could be expected to be overtopped under year 2000 plan and 100-year recurrence interval peak flood discharge conditions. The entire north bank could be expected to be breached by flood waters under the 100-year recurrence interval peak flood flow that could be expected to occur under uncontrolled development conditions. An approximately one acre area devoted primarily to parking and storage on the north side of the channelized reach could be expected to incur flood damage if the channel were overtopped by the 100-year recurrence interval flood occurring under year 2000 plan conditions. Flooding in this area would be a relatively rare event, since an approximately 25- to 50-year discharge under the year 2000 plan conditions would be needed to breach the north bank.

Concluding Statement: Based on the analyses conducted on flood stage profiles developed for the channelized reach of the Menomonee River between the W. Wisconsin Avenue viaduct and N. 45th Street under year 2000 plan conditions and under uncontrolled development conditions, certain actions appear warranted. The west bank of the Menomonee River between the W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge (River Mile 4.24) and all or a portion of both banks of the River between the railroad bridge and N. 45th Street will not contain the selected design flow—the 100-year recurrence interval discharge under year 2000 plan conditions. Presumably, following sound engineering practice, major channelization was earlier selected for this reach based on an economic analysis of alternatives and the channel was designed to convey the 100-year recurrence interval discharge. Inasmuch as the channel cross-section in this reach will not safely convey the 100-year flood flow as developed under the Menomonee River watershed planning program for year 2000 plan conditions, it is prudent to supplement the existing channel works—which represent a major capital investment already made—with construction of a floodwall on the low banks and with installation of necessary backwater gates and storm water pumping stations near the end of storm sewer outfalls.

SUMMARY

Floodland management may be defined as the planning and implementation of a combination of measures intended to reconcile the floodwater conveyance and storage function of floodlands with the space and related social and economic needs of society. This chapter presents a recommended floodland management plan element for inclusion in a comprehensive plan for the Menomonee River watershed. Alternatives to the recommended element also are presented, together with a comparative evaluation of the recommended element and the alternatives thereto.

The available floodland management measures from which the recommended management plan element was snythesized may be broadly subdivided into two categories: structural measures and nonstructural measures. A total of five structural floodland management measures were identified for possible application, either individually or in various combinations, to specific flood-prone reaches of the watershed, including: 1) floodwater storage facilities, 2) floodwater diversion facilities, 3) dikes and floodwalls, 4) major channel modifications, and 5) bridge and culvert modifications or replacement. Ten nonstructural measures were identified consisting of: 1) reservation and acquisition of floodlands for recreational and related open space use, 2) floodland use regulation, 3) regulation of land use outside of the floodlands, 4) federal flood insurance, 5) lending institution policies, 6) realtor policies, 7) community utility policies, 8) emergency programs, 9) structure floodproofing, and 10) structure removal. Structural measures tend to be more effective in achieving the objectives of floodland management in riverine areas that have already been urbanized while nonstructural measures are preventative in that they are generally more effective in riverine areas that have not yet been developed for flood damage-prone uses but have the potential for such development.

A hydrologic and hydraulic flood flow simulation model was used to evaluate the response of the Menomonee River watershed to seven land use-floodland development conditions in order to quantify the influence of differing land use patterns both within and outside of the floodlands on the flood flow behavior of the watershed. The simulation model studies indicated that urbanization of lands outside of the floodlands, which increases the extent of impervious surfaces and decreases runoff times, may be expected to produce marked increases in flood flows for any given major rainfall or rainfall-snowmelt event. The principal effect of urban development in the floodlands is to diminish the storage capacity of the floodlands and to decrease flow times in the stream system, thus contributing to the increase in downstream discharges and stages. The seven land use-floodland development conditions examined in the watershedwide simulation analysis were: 1) existing (1975) land use and floodland conditions, 2) presettlement, "natural" land use and floodland conditions, 3) year 1950 land use and floodland conditions, 4) year 2000 plan land use and floodland conditions, 5) complete urbanization of lands outside of the floodlands with no additional floodland development, 6) complete development of the floodlands with no additional development outside of the floodlands, and 7) complete development of lands within and outside of the floodlands. These seven floodland and non-floodland urbanization configurations were selected to encompass the full spectrum of combinations of land use and stream channel and related floodland storage and conveyance capacity that have existed, or could exist, in the Menomonee River watershed. Therefore, the simulation model results were expected to yield a corresponding full spectrum of hydrologic-hydraulic responses to various patterns of urbanization within the watershed. The hydrologic-hydraulic impact of alternative land use-floodland development conditions was examined by comparing flood discharge-frequency relationships and flood stage profiles at selected points throughout the watershed.

The simulation model studies indicated that, for the watershed as a whole, the urbanization that has occurred to date has produced a significant increase in the magnitude of major floods. The ratio of 100-year recurrence interval discharges under existing conditions to such discharges under the presettlement, "natural" conditions was found to range from 1.0 to 4.4 with a median value of 1.5. A comparison of simulated discharge-frequency relationships for the Menomonee River watershed under existing (1975) conditions to those that could be expected to exist under Condition 7—the "worst possible" condition—clearly indicates the potential negative impact that man can still have on the flood flow characteristics of the Menomonee River watershed. The ratio of the 100-year recurrence interval discharge under complete development conditions and existing conditions ranges from 1.4 to 6.4 within a median value of 1.9. The associated increases in the 100-year recurrence interval flood stage profiles range from approximately 0.5 to 9.0 feet at the 10 locations, with a median value of 4.75 feet.

The year 2000 watershed land use plan, as described in Chapter III of this volume, is intended to balance the socio-economic need for space within the watershed against the ability of the underlying natural resource base of the watershed to sustain that need without creating new, or intensifying existing, environmental and developmental problems and without a significant loss in the overall quality of the environment for life within the watershed. The proposed land use plan for the watershed calls for accommodation of a 12 percent increase in population with a 20 percent increase in urban land use. A key proposal in the land use plan is the prohibition of any additional floodland fill or development. The hydrologic-hydraulic simulation studies indicate that flood flow characteristics throughout the watershed under year 2000 plan land use-floodland development conditions can be expected to be very similar to 1975 conditions. For example, the ratio of the 100-year recurrence interval peak flow discharges under year 2000 plan conditions and existing conditions ranges from 1.0 to 1.5 throughout the watershed with the median value of only 1.1. Similarly the 100-year recurrence interval flood stage profile under year 2000 plan conditions relative to the existing conditions may be expected to increase from 0.0 to approximately 1.5 feet with the median value of only 0.75 feet. The anticipated incremental discharges and stages associated with the year 2000 land use plan conditions are relatively small compared to those which could occur under uncontrolled development conditions within the watershed.

The economic analyses of alternative floodland management measures require that the flood damage susceptibility of a river reach be quantified in monetary terms for comparison to the cost of alternative floodland management measures. Information derived from the historic flood survey, combined with the results of hydrologic-hydraulic simulation, were used to select a total of 25 reaches in the Menomonee River watershed for which detailed determination of monetary flood risks were carried out. The selected reaches consisted of portions of the Menomonee River, the Little Menomonee River, Underwood Creek, Honey Creek, Butler Ditch, and Lilly Creek. The selected reaches are located in the Cities of Milwaukee and Wauwatosa in Milwaukee County, the City of Mequon in Ozaukee County, and the City of Brookfield and in the Villages of Menomonee Falls and Elm Grove in Waukesha County. The total average annual monetary flood risks for all of the 25 selected reaches confined under existing land use-floodland development conditions in the watershed were estimated at $630,500.

In addition to computing monetary flood risks in the flood-prone reaches under existing land use-floodland development conditions, average annual monetary flood risks were also computed under year 2000 land use plan conditions, and Conditions 5, 6, and 7 in order to further quantify the likely consequences of planned versus unplanned incremental urbanization in the Menomonee River watershed. The total estimated average annual monetary flood risks for the 25 selected urbanized flood-prone reaches under year 2000 plan conditions, and under Conditions 5, 6, and 7 are, respectively, $1,096,000, $1,896,000, $1,140,000, and $2,641,000. The analysis of monetary flood risks under existing and hypothetical future conditions clearly indicates that the manner in which presently undeveloped land, both within and outside of the watershed floodlands, is used in the future may be expected to be a primary determinant of future monetary flood damages experienced in the Menomonee River watershed. The studies further indicate that adoption and implementation of the year 2000 land use plan would serve to minimize increases in flood damages.

Under the Menomonee River watershed planning program, 25 potential surface floodwater storage locations were identified and screened to determine their potential to provide flood protection as well as possibly to accommodate other uses such as water-related recreational activities. Based upon a screening of the 25 sites, 11 were selected for further hydrologic-hydraulic and, in some cases, for economic analyses, the objective being to identify one storage site, or combination of such sites, that could mitigate flood damages in a technically practicable, economically sound, and environmentally acceptable manner. The analyses of the 11 selected potential surface detention storage sites consisted of investigation of the individual behavior of four of the larger sites followed by an examination of the likely benefits to be derived from an integrated system composed of all 11 sites with this latter analysis being focused on significant reduction in flood problems along the lower Menomonee River in the Cities of Wauwatosa and Milwaukee.

Although the system of 11 detention reservoirs was found to be technically impractical, one of the individual sites was found to constitute a technically practical and economically feasible floodland management alternative.

That was a detention reservoir located on the Dousman Ditch at Gebhardt Road in the City of Brookfield, upstream of flood-prone reaches along Underwood Creek in the City of Brookfield and Village of Elm Grove. Construction of this detention reservoir is estimated to entail an annual cost of $46,200 and produce an annual benefit of $196,000 in flood damage abatement, yielding a favorable benefit-cost ratio of 4.2. This reservoir would serve to eliminate almost half of the flood damages to downstream areas along Underwood Creek in the City of Brookfield and the Village of Elm Grove.

A preliminary assessment also was made of the technical and economic feasibility of constructing mined storage chambers in the bedrock underlying the lower portions of the watershed and using these chambers for the temporary storage of floodwaters. While such a subsurface storage arrangement was found to be technically feasible, it was apparent from the preliminary screening that subsurface storage alternatives would be economically unsound and, therefore, this alternative was eliminated from further examination.

In the consideration of alternative structural flood control measures, it was recognized that Lake Michigan might provide a convenient discharge point for floodwaters diverted from within the Menomonee River watershed. Therefore, diversion of flood flows to Lake Michigan also was subjected to a preliminary technical and economic screening. In particular, two floodwater diversion possibilities were examined—direct diversion to Lake Michigan via a large conduit and indirect diversion to the Lake through an enlarged and extended deep tunnel system that is currently being examined as an alternative solution to the combined sewer overflow problem in the Milwaukee-Metropolitan area. While such diversions were found to be technically feasible, the diversions were found to be economically unsound and, therefore, were eliminated from further examination.

The watershed planning program also carefully examined the possibility of applying one or more primarily structural measures on a community-by-community basis in those riverine areas experiencing the most severe flood problems. The communities identified for inclusion in this analysis were the Village of Elm Grove, the City of Brookfield, the Village of Menomonee Falls, the City of Wauwatosa, the City of Mequon, and the City of Milwaukee. The floodland management measures considered for each of the above communities included structure floodproofing and removal, channel modification, dike and floodwall construction, and bridge and culvert alteration or replacement.

The following six technically practicable and economically feasible alternatives were developed for resolution of the flood problems along Underwood Creek in the Village of Elm Grove: (1) detention storage which would produce an annual benefit of $160,000 at an annual cost of $37,700 for a benefit-cost ratio of 4.24; (2) structure floodproofing and removal which would produce an annual benefit of $362,800 at an annual cost of $118,800 for a benefit-cost ratio of 3.05; (3) major channel modification which would yield an annual benefit of $362,800 at an annual cost of $233,300 for a benefit-cost ratio of 1.56; (4) dikes and floodwalls which would produce an annual benefit of $362,800 at an annual cost of $314,500 for a benefit-cost ratio of 1.15; (5) a composite storage-major channelization alternative which would produce an annual benefit of $362,800 at an annual cost of $244,300 for a benefit-cost ratio of 1.49; and 6) a composite storage-major channelization-intermediate channelization-floodproofing alternative which would produce an annual benefit of $362,800 at an annual cost of $214,200 for a benefit-cost ratio of 1.69. After careful review of the technical and economic aspects of each of these six alternatives and after due consideration of the various nontechnical and noneconomic positive and negative features of each as identified under the planning program, it is recommended that the composite storage—major channelization—intermediate channelization—floodproofing alternative be used to resolve existing and probable future flood problems along Underwood Creek within the Village of Elm Grove.

The following four technically practicable and economically feasible alternatives were developed for resolution of the flood problems along Underwood Creek in the City of Brookfield: (1) detention storage which would produce an annual benefit of $37,700 at an annual cost of $8,500 for a benefit-cost ratio of 4.44; (2) structure floodproofing and removal which would produce an annual benefit of $73,500 at an annual cost of $65,700 for a benefit-cost ratio of 1.12; (3) channel modification in combination with structure floodproofing and removal and bridge alteration which would produce an annual benefit of $73,500 at an annual cost of $63,600 for a benefit-cost ratio of 1.16; and (4) storage in combination with replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and structure floodproofing and removal which would produce an annual benefit of $73,500 at an annual cost of $46,900 for a benefit-cost ratio of 1.57. After careful review of the technical and economic aspects of these three alternatives and after due consideration of the various nontechnical and noneconomic positive and negative features of each as identified under the planning program, it is recommended that upstream storage in a detention reservoir in combination with repalcement of the railroad bridge and structure floodproofing and removal be used to resolve existing and probable future flood problems along Underwood Creek within the City of Brookfield.

After examining several alternatives, it was determined that the only technically practicable and economically feasible means for resolution of the flood problem along Butler Ditch in the City of Brookfield is structure floodproofing which would produce an annual benefit of $2,300 at an annual cost of $400 for a benefit-cost ratio of 5.75. Therefore, it is recommended that structure floodproofing be used to resolve existing and probable future flood problems along Butler Ditch within the City of Brookfield.

Two technically practicable alternatives were developed for resolution of the flood problems along the main stem of the Menomonee River in the Village of Menomonee Falls: (1) structure floodproofing and removal which would produce an annual benefit of $36,300 at an annual cost of $19,300 for a benefit-cost ratio of 1.88 and (2) major channel modification which would yield an annual benefit of $36,300 at an annual cost of $136,200 for a benefit-cost ratio of 0.27. After careful review of the technical and economic aspects of each of these two technically practicable alternatives and after due consideration of various nontechnical and noneconomical positive and negative features and in light of the Village commitment to channelization as reflected by the location, size, elevation, and grades of existing and proposed storm sewers and storm sewer outfalls, the Menomonee River Watershed Committee recommended that channelization be used to resolve existing and probable future flood problems along the Menomonee River within the Village of Menomonee Falls.

The following technically practicable alternatives were developed for resolution of the flood problems along Lilly Creek in the Village of Menomonee Falls: (1) structure floodproofing and removal which would produce an annual benefit of $109,400 at an annual cost of $79,500 for a benefit-cost ratio of 1.38 and (2) major channelization which would produce an annual benefit of $109,400 at an annual cost of $158,200 for a benefit-cost ratio of 0.69. After careful review of the technical and economic aspects of each of these two alternatives and after due consideration of the various nontechnical and noneconomic positive and negative features of each and in light of the Village commitment to channelization as reflected by location, size, elevation, and grades of existing and proposed storm sewers and storm sewer outfalls, the Menomonee River Watershed Committee recommended that the channelization alternative be used to resolve existing and probable future flood problems along Lilly Creek in the Village of Menomonee Falls.

The following three technically practical and economically feasible alternatives were developed for resolution of the flood problems along the Menomonee River in the City of Wauwatosa between the eastern limits of the City and Harwood Avenue: (1) structure floodproofing and removal which would produce an annual benefit of $330,900 at an annual cost of $216,800 for a benefit-cost ratio of 1.53; (2) major channel modification which would produce an annual benefit of $330,900 at an annual cost of $294,700 for a benefit-cost ratio of 1.12; (3) dikes and floodwalls which would produce an annual benefit of $330,900 at an annual cost of $194,900 for a benefit-cost ratio of 1.70. A channelization-structure floodproofing and removal alternative was also developed which would produce an annual benefit of $330,900 at an annual cost of $381,200, or a benefit-cost ratio of 0.87. After careful review of the technical and economic aspects of each of these four alternative plan elements and after due consideration of the various nontechnical and noneconomic positive and negative features of each as identified under the planning program, the Menomonee River Watershed Committee recommended that the channelization-structure floodproofing and removal alternative be used to resolve the existing and probable future flood problems along the Menomonee River in the City of Wauwatosa between the eastern limits of the City and Harwood Avenue. This recommendation was based, in part, on three intangible factors. First, retention of the Harwood Avenue-N. 70th Street reach in its present natural condition would be in harmony with long-range Village plans to rejuvenate the "Old Village Center" focusing on the various amenities associated with the Menomonee River. Second, the structure removal component would permit a needed expansion of Hart Park. Third, the structure removal component would provide a long-range solution to decreasing property values in the residential area immediately east of Hart Park.

After examining several alternatives, it was determined that the only available technically practical and economically feasible alternative for resolution for flood problems along the Menomonee River in the City of Wauwatosa between Harwood Avenue and W. Hampton Avenue is structure floodproofing and removal which would produce an annual benefit of $125,400 at an annual cost of $59,900 for a benefit-cost ratio of 2.09. Similarly, the only technically practicable and economically feasible alternative for resolution of flood problems along the Honey Creek in the City of Wauwatosa between the Menomonee River and Wisconsin Avenue is structure floodproofing which would produce an annual benefit of $700 at an annual cost of $200 for a benefit-cost ratio of 3.50. Finally, the only technically practicable and economically feasible alternative for resolution of the flood problem along Underwood Creek in the City of Wauwatosa between the Menomonee River and the Zoo Freeway is structure floodproofing which would produce an annual benefit of $3,900 at an annual cost of $1,900 for the benefit-cost ratio of 2.05. It is, therefore, recommended that structure floodproofing and removal be used to resolve existing and probable future flood problems in the City of Wauwatosa along the Menomonee River between Harwood Avenue and W. Hampton Avenue, along Honey Creek between the Menomonee River and W. Wisconsin Avenue, and along Underwood Creek between the Menomonee River and the Zoo Freeway.

After examining several alternatives, it was determined that the only technically practicable and economically feasible alternative available for resolution of the residential flood damage problem along the Little Menomonee River in the City of Mequon in the vicinity of Mequon Road is structure floodproofing which would produce an annual benefit of $2,300 at an annual cost of $800 for benefit-cost ratio of 2.88. It is, therefore, recommended that the structure floodproofing be used to resolve existing and forecast flood problems along the Little Menomonee River in the City of Mequon immediately north of Mequon Road.

Based on an analysis of several alternatives, it was determined that floodproofing is the only technically practicable and economically feasible means for resolution of the flood problem along the Menomonee River in the City of Milwaukee between N. 45th Street and Hawley Road. This approach would produce an annual benefit of $48,600 at an annual cost of $20,300 for a benefit-cost ratio of 2.39. Therefore, it is recommended that floodproofing be used to resolve existing and probable future flood problems along the Menomonee River in the City of Milwaukee between N. 45th Street and Hawley Road.

The simulation model was used to assess the net impact of the recommended 10.84 miles of channel modifications and the 215 acre-feet detention storage on a full range of flood flows by comparing flood flows at selected locations in the watershed under year 2000 planned land use-floodland development conditions with and without the recommended channel modifications and detention storage. The analysis indicated that the recommended structural flood control works may be expected to result in from a 90 percent decrease to a 50 percent increase in 100-year recurrence interval peak flood discharges. There should, however, be no significant adverse effects associated with the increases in discharge primarily because the recommended channel works would be sized and constructed so as to safely contain and convey the increased flood flows.

Analyses conducted under the watershed planning program resulted in the identification of 48 bridges and culverts that could be expected, by virtue of inadequate capacity and overtopping of the approach roads or the structure, to interfere with the operation of the highway and railroad transportation system during major flood events. Of the total number of substandard bridges and culverts so identified, 16 are located on minor or collector streets, 21 are located on arterial streets and highways other than freeways and expressways, and 11 are located on freeways, expressways, and railroads. It is recommended that when these 48 structures are modified or replaced by the responsible highway agencies or by the railroad companies as part of necessary highway and railroad improvement programs, that these crossings should be designed to provide adequate capacity in accordance with the standards set forth in Chapter II of this volume. It is also recommended, in accordance with the adopted standards set forth in Chapter II of this volume, that all new or replacement bridges and culverts be designed so as to accommodate the 100-year recurrence interval flood discharge under year 2000 plan conditions without raising the corresponding peak stage by more than 0.5 feet above the peak stage as established in the adopted comprehensive watershed plan.

Of the 10 available nonstructural floodland management measures identified for possible application in the Menomonee River watershed, the following three were found to be particularly effective for minimizing aggravation of existing problems and for preventing development of future flood problems: (1) reservation of floodlands for recreation-related open space uses through measures such as private development or public acquisition of the land or of an easement; (2) floodland use regulations as accomplished through zoning, land subdivision, sanitary, and building ordinances; and (3) regulation of land use outside of the floodlands, also through zoning, land subdivision, sanitary, and building ordinances. These nonstructural floodland management measures are intended for the regulation or control of land use both within and outside of the floodlands of the watershed. It is recommended that the use of floodland areas for outdoor recreation and related open space activities be emphasized and carried out not only to implement the land use plan—particularly the primary environmental corridor plan subelements which seek to preserve recreational, aesthetic, ecologic, and cultural resources of the watershed—but also to minimize the aggravation of the existing flood problems and development of new flood problems. In order to fully protect the floodlands of the watershed in accordance with this recommendation, existing floodland and related regulations would have to be modified for explicit application to Menomonee River watershed floodlands or new floodland regulations prepared by the following municipalities: the Cities of Brookfield, Mequon, Milwaukee, Wauwatosa, West Allis, and Greenfield and the Villages of Elm Grove, Germantown, Menomonee Falls, and Butler. Floodland and related regulations are an integral part of the primary environmental corridor protection subelement of the recommended land use plan. In addition, and because of the demonstrated hydrologic-hydraulic impact of land use development patterns outside of the floodlands on the extent and severity of flooding, it is also recommended that land use regulation controls outside of the floodlands, as needed to achieve the year 2000 land use plan as described in Chapter III of this report, be viewed as a floodland management measure for the Menomonee River watershed.

Although the availability of federal flood insurance does not resolve any existing flood problems, it does provide a means for distributing monetary flood losses in the form of an annual flood insurance premium and, in those situations where insurance premiums are subsidized, the federal flood insurance program also provides a way of reducing monetary flood losses to the owner. Significant steps have been taken by watershed communities towards participation in the federal flood insurance program in that all the seven cities and six villages located wholly or partly in the Menomonee River watershed, as well as the unincorporated areas of the watershed in Washington and Waukesha Counties, have taken the necessary steps to become eligible to participate in the federal flood insurance program. Furthermore, the U.S. Department of Housing and Urban Development has authorized insurance rate studies for the Cities of Greenfield, Milwaukee, Wauwatosa, New Berlin, and Brookfield; and for the Villages of Menomonee Falls and Butler. It is recommended that the U.S. Department of Housing and Urban Development, in cooperation with Wisconsin Department of Natural Resources, authorize the conduct of additional insurance rate studies in the following communities located wholly or partly in the watershed which have been identified as having flood hazard areas: the Cities of West Allis and Mequon and the Villages of Germantown and Elm Grove. It is further recommended that the contractors retained by the U.S. Department of Housing and Urban Development to conduct the flood insurance rate studies make maximum use of the flood hazard data developed under the watershed program. Finally, it is recommended that owners of property in flood-prone areas purchase flood insurance to provide some financial relief for losses sustained during future floods.

Under the national flood insurance program, private lending institutions require the purchase of flood insurance on property in flood-prone areas before granting a mortgage for a structure on the property. It is recommended that lending institutions continue to determine the flood-prone status of properties prior to granting of a mortgage, and that the principal source of flood hazard information be that developed under the watershed planning program. A 1973 executive order by the Governor of Wisconsin urges real estate brokers, salesmen, and their agents to inform potential purchasers of property of any flood hazard which may exist at the site. It is recommended that this program be continued so that potential property buyers are aware of the threat of life and property posed by flood events.

Local communities may adopt policies relating to the extension of certain public utilities and facilities in recognition of the likely influence of the location and size or capacity of such utilities and facilities on the location of new urban development. It is recommended that the policies of governmental units and agencies having responsibility for such utilities and facilities within the watershed be designed to complement the floodland regulation recommendations for the Menomonee River watershed and the recommended primary environmental corridor protection plan subelement.

As a floodland management measure, an emergency program is intended to minimize the damage and disruption associated with flooding. It is recommended that each watershed community develop a warning system or procedure to provide floodland residents and other property owners with information about floods already in progress. In developing a warning system, it is suggested that the following measures be considered: monitoring of National Weather Service flash flood watch bulletins and flash flood warning bulletins during periods when rainfall or snowmelt are anticipated, emergency messages broadcast to community residents over radio and television, use of police patrol cars or other vehicles equipped with public address systems, and use of warning sirens having a special pattern to indicate a flood threat.

Continuous recording stream gaging stations, as well as partial record streamflow stations and crest stations located within the Menomonee River watershed provide critical data required for future rational management of the surface water resources. The records from such gaging stations will serve as indicators of the hydrologic and hydraulic effect of headwater urbanization. Moreover, discharge-frequency relationships, floodstage profiles, and other information obtained from gaging stations can be used to periodically refine the hydrologic-hydraulic simulation model developed and used in the Menomonee River watershed study. It is recommended that the continuous streamflow monitoring gages temporarily installed at the N. 70th Street crossing of the Menomonee River in Wauwatosa and on the Menomonee River at Pilgrim Road (CTH YY) in the Village of Menomonee Falls for purposes of the International Joint Commission Menomonee River Pilot Watershed Study continue to be operated as permanent monitoring stations subsequent to completion of that research project. It is also recommended that two of the three partial record stations operated in the basin by the U.S. Geological Survey—the Freistadt gage on the Little Menomonee River and the Milwaukee gage on Honey Creek—continue to be operated and that the Village of Menomonee Falls, the City of Milwaukee, and the Milwaukee Metropolitan Sewerage Commissions continue to maintain the existing crest and staff gage network. It is also recommended that the following communities located on the major stream system of the Menomonee River watershed establish and maintain a network of crest stage or staff gages to provide for the acquisition of high water data during future major flood events: the Cities of Mequon and Brookfield and the Villages of Germantown and Elm Grove.

The existence in the Menomonee River watershed of 12 semipermanent structures located throughout the basin so as to receive base flow or direct runoff from a variety of land uses and land use combinations and equipped with sophisticated streamflow and water quality monitoring devices offers a unique opportunity for continued hydrologic, hydraulic, and water quality research in southeastern Wisconsin. Therefore, it is recommended that local, state, and federal agencies and educational and research institutions having responsibilities in water resource and water-resource-related areas in the watershed give consideration to development of research projects, educational programs, and other special studies that could incorporate all or portions of the existing and extensive water quality-quantity monitoring network within the Menomonee River watershed.

A backwater analysis, employing a range of Lake Michigan stages and River flood flows, was conducted for that portion of the Menomonee River watershed lying within the industrial valley—defined as the riverine area extending from the confluence of the Menomonee and Milwaukee Rivers to the W. Wisconsin Avenue viaduct—in order to more precisely define the flood problems of the industrial valley. These studies indicated that flood stages on the Menomonee River downstream from River Mile 1.75 at about N. 27th Street are primarily determined by a combination of Lake Michigan stages and Menomonee River flood flows. Upstream of River Mile 1.75, flood stages are determined primarily by River flood flows, channel geometry, and the presence of hydraulic control structures such as bridges and a dam.

Based on the backwater analysis, it was concluded that the flood protection elevation of 584.6 feet above Mean Sea Level Datum, or 4.0 feet above City of Milwaukee Datum, as established by the Milwaukee-Metropolitan Sewerage Commissions, can continue to be applied to that reach of the Menomonee River downstream from River Mile 1.75. A new flood protection elevation of at least two feet above the 100-year recurrence interval peak flood stage profile for year 2000 land use plan conditions, however, should be established along the Menomonee River in the industrial valley upstream of River Mile 1.75, superseding the flood protection elevation of 584.6 feet Mean Sea Level Datum presently established for that reach by the Sewerage Commissions. Consideration should be given to removal of The Falk Corporation Dam in order to reduce flood stages at the earthen dike protecting the south boundary of the Chicago, Milwaukee, St. Paul, and Pacific Railroad yard. In the event that The Falk Corporation Dam is required to be retained to provide a supply of industrial cooling water, the crest of the dike protecting the railroad yard should be raised. In order to protect the residential area lying east of the Menomonee River between IH 94 and the W. Wisconsin Avenue viaduct from flooding under probable future flow conditions, a flood wall should be constructed along the east bank of the River in this reach, and necessary backwater gates and storm water pumping stations should be installed near the end of storm sewer outfalls.

A similar analysis of flood stage profiles was conducted for the channelized reach of the Menomonee River bounded on the downstream end by the W. Wisconsin Avenue viaduct and on the upstream end by N. 45th Street. The study indicated that the 0.16-mile-long portion of this reach between the W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge does not have sufficient capacity to convey the 100-year recurrence interval flood flow of the Menomonee River under year 2000 plan conditions and that the west side of the channel in this reach could be expected to be flooded along peak flows. Furthermore, all or a portion of both sides of the channel between the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and N. 45th Street will not contain the 100-year recurrence interval peak flood flow of the Menomonee River under year 2000 land use plan conditions. Presumably following sound engineering practice, major channelization was selected for this reach based on an economic analysis of alternatives, and the channel was designed to convey the 100-year recurrence interval discharge. Inasmuch as the channel cross-section in this reach will not safely convey the 100-year flood flow as developed under the Menomonee River watershed planning program for year 2000 land use plan conditions, the existing channel works—which represent a major expenditure of public funds—should be supplemented by the construction of flood walls on the low banks and the installation of necessary backwater gates and storm water pumping stations near the storm sewer outfalls.

Chapter V

ALTERNATIVE WATER QUALITY MANAGEMENT MEASURES

INTRODUCTION

The inventory and analysis phases of the Menomonee River watershed planning program identified certain water resource and water resource-related problems including flooding and water pollution. As stated in Chapter I, Volume 1, the overriding objective of the Menomonee River watershed planning program is to assist in the abatement of these water resource and water resource-related problems by developing a workable plan which can be used to guide development within the watershed into a safer, more healthful, and more economic pattern; a pattern which is properly related to the sustaining ability of the underlying natural resource base without intensifying existing or creating new developmental and environmental problems. The purpose of this chapter is to develop a water quality management plan element from which an integrated water resources management plan for the watershed can be synthesized. More specifically, the purpose of this chapter is:

1. To analyze the extent to which water quality management recommendations pertinent to the Menomonee River watershed but developed under other Commission planning programs will mitigate or eliminate the pollution problems that exist in the watershed and

2. To present alternative water quality management measures intended to resolve watershed water quality problems not addressed in other Commission studies.

Development of the water quality management plan element for the Menomonee River watershed differs from development of the floodland management plan element for the watershed in that, whereas the Menomonee River watershed planning program constitutes the first comprehensive attempt to resolve existing flood problems and to prevent the occurrence of future flood problems in this watershed, plan elements prepared under other Commission studies have already included recommendations for resolution of some of the water quality problems within the watershed. Therefore, preparation of the water quality management plan element for the Menomonee River watershed plan emphasized refinement and extension of water quality recommendations made under other Commission studies. This water quality management chapter, therefore, constitutes not so much an exploration of alternatives—as did the previous floodland management chapter—as an expanded evaluation of the expected impact of committed decisions regarding primarily point sources of pollution in order to determine if additional nonpoint source management measures are required and what might be the nature of those measures.

The water quality management measures described herein were designed and should be considered as adjuncts to the basic land use development proposals advanced in Chapter III of this volume to facilitate the attainment of regional and watershed development objectives. The water quality management measures are thus subordinate to the basin-wide land use plan element, and the incremental costs of these measures can be separated from those of the basin-wide land use plan element.

As noted in Chapter I of this volume, the evaluation of a particular alternative measure relative to other alternatives intended to resolve problems is a sequential process during which the measure is subjected to several levels of review including technical, economic, financial, legal and administrative feasibility, and political acceptability. In anticipation of making a comparative evaluation of the various alternative water quality management measures and the selection of a recommended comprehensive watershed plan, the technical, economic, and environmental aspects of each alternative water quality management measure are presented in this chapter.

With respect to the organization of the material presented in this chapter, surface and ground water quality problems evident in the watershed are briefly reviewed together with the likely sources of those problems and the steps that have already been taken or have been committed to be taken for resolution of the water quality problems. The assumptions underlying the analyses conducted during the preparation of this chapter are stated and followed by a discussion of the technical, economic, and environmental aspects of alternative solutions to the unusual creosote pollution problem in the Little Menomonee River. The results of simulation studies intended to show the consequences of removing discharges of municipal sewage treatment plant effluent from the stream system and the likely consequences of planned incremental urban development and of land management measures on surface water quality are described, followed by an analysis of measures available for resolution of diffuse source pollution. The significance of sanitary sewer system flow relief devices is discussed and the chapter concludes with a discussion of accessory water quality management considerations.

BASIS FOR THE DEVELOPMENT AND ANALYSIS OF ALTERNATIVE WATER QUALITY MANAGEMENT PLAN ELEMENTS

In an urban and urbanizing setting like the Menomonee River watershed, man's activities affect, and are affected by, the quality of surface and ground waters. Waters are defined herein to be polluted when foreign substances caused by, or related to, human activity are in such a form and concentration as to render the water unsuitable for a desired beneficial use. Chapter VII, Volume 1 of this report, describes the surface water and ground water pollution problems in the Menomonee River watershed as revealed by an examination of historic data. These pollution problems are briefly reviewed here along with the efforts that are already underway or are planned to resolve the pollution problems. The characteristics of watershed pollution problems and the nature of the in-process or planned remedial measures form the basis for the supplemental water quality analysis and alternative water quality management measures described in this chapter.

Surface Water Pollution

A careful examination of the available water quality data for the Menomonee River watershed stream system for the period 1951 through 1974 indicates that the surface waters are severely polluted. Of the seven possible categories of pollution, six—toxic, organic, nutrient, pathogenic, sediment, and aesthetic—are known to exist in the Menomonee River watershed. The seventh category of pollution—thermal—is not known to exist in the watershed.[1] The surface water pollution in the watershed is widespread in that it occurs on the Little Menomonee River, Underwood Creek, Honey Creek, and Little Menomonee Creek, in addition to the Menomonee River. This indicates that pollution problems may not be solely attributed to the effluent from municipal sewage treatment plants or other point sources.

The most serious type of surface water pollution present in the watershed is pathogenic pollution as indicated by the widespread occurrence of high fecal coliform bacteria counts. These fecal coliform counts, which are indicative of the presence of human and animal wastes, appear to be attributable to sanitary and combined sewer overflows and runoff from the rural and urban land surfaces. The second most serious pollution problem is that of excessive nutrients, particularly phosphorus, under all flow conditions. The third most serious pollution problem is organic pollution reflected by occasional widespread substandard dissolved oxygen levels. This problem is most prevalent along the main stem of the Menomonee River and appears to be primarily attributable to discharges from municipal sewage treatment plants. In addition to pathogenic, nutrient, and organic pollution, toxic pollution in the form of high lead concentrations and the presence of creosote are causes for concern, as is the aesthetic pollution that pervades the watershed surface water system.

The adopted water use objectives for the stream system call for recreational use and propagation of fish and aquatic life throughout most of the watershed stream system—exceptions consist of Honey Creek, the South Branch of Underwood Creek, the lower portion of Underwood Creek, and the extreme lower reaches of the Menomonee River. The condition of the surface waters is such, however, that the watershed stream system currently receives only minimal use because of the severe pollution that exists.

Groundwater Pollution

About 14 percent of the watershed population, located primarily in the City of Brookfield, the Village of Menomonee Falls, the Village of Germantown, and the City of Mequon, is served by private groundwater supplies which generally use relatively shallow wells constructed in the glacial till and underlying and interconnected dolomitic bedrock. About 88 percent of the area served by such wells also uses onsite sewage disposal systems and is located on soils not well suited for the use of such systems. As a result, examples of surface water pollution evidenced by offensive odors and septic system discharge appearing in drainage swales and other low lying areas have developed in recent years. An even more serious matter of concern is the threat to the health of area residents as a result of either direct contact with the septic tank system discharge on the ground surface or as a result of the pollution of the private groundwater supplies.

Six percent of the watershed population is served by four public utilities which rely on groundwater. Inventories conducted under the watershed planning program indicate that none of these utilities is currently experiencing serious water quality or quantity problems nor do they expect such problems to develop in the immediate future. Moreover, the groundwater utilities are considering the results of an engineering consultant study that presents an analysis of alternative intermunicipal water supply systems involving communities in and near the Menomonee River watershed.

Certain commercial and industrial water users in the Menomonee River watershed are self-supplied in that they satisfy all or part of their water needs from private wells or by pumping directly from the streams. Various types of cooling processes account for most of this water use. Investigations carried out under the watershed study reveal that self-supplied industrial-commercial water users are not experiencing any serious quality or quantity problems nor is their pumping interfering with that of the four groundwater utilities.

Pollution Sources

The following types of pollution sources have been identified in the Menomonee River watershed: municipal sewage treatment plants, sanitary and combined sewerage system flow relief devices, industrial discharges, urban stormwater runoff, agricultural and other rural runoff, and onsite waste disposal systems.

Five municipal sewage treatment facilities existed in the watershed when the watershed planning program was initiated in 1972—the Village of Germantown Old Village and County Line Road plants, the Village of Menomonee

[1] *As discussed in Chapter VII, Volume 1 of this report, there are discharges of water having a temperature above ambient water temperature into the watershed stream system, such as the discharge of cooling water into the South Menomonee Canal by the Wisconsin Electric Power Company, but such heated discharges are not known to produce thermal pollution problems.*

Falls Pilgrim Road and Lilly Road plants, and the Village of Butler overflow-chlorination facility. The Germantown County Line Road facility was permanently removed from service on November 2, 1973, and its tributary area connected to the Old Village plant.

Sanitary sewage enters the surface water system of the Menomonee River watershed through five types of sewerage system flow relief devices: combined sewer outfalls, crossovers, bypasses, relief pumping stations, and portable pumping stations. A total of 25 combined sewer outfalls together with 102 other flow relief devices are known to exist in the watershed with 80 percent of the 127 total flow relief devices discharging directly to the Menomonee River. Forty percent of the flow relief devices, including all of the 25 combined sewer outfalls, is located within the Milwaukee County portion of the watershed.

Industrial discharges, consisting primarily of cooling and process water, directly and indirectly enter the watershed stream system. A total of 44 industrial discharges—about half of which consist of cooling water discharges—are known to exist within the watershed with over three-fourths discharging to the Menomonee River and about 85 percent being located in Milwaukee County. Although these discharges probably vary markedly in quality, very little data are currently available, a deficiency that will be rectified with the continued implementation of the Wisconsin Pollutant Discharge Elimination System. An industrial-related pollution source is the creosote that remains in the bottom muds of a reach of the Little Menomonee River in Milwaukee County.

Onsite waste disposal systems constitute a significant potential source of surface and groundwater pollution in the watershed. About 14 percent of the watershed population is served by private groundwater supplies and about 88 percent of the area served by such supplies also uses onsite waste disposal systems and is located on soils not well suited for the use of such systems. Potential groundwater pollution sources in the form of onsite waste disposal systems are located primarily in the Cities of Brookfield and Mequon and the Villages of Germantown and Menomonee Falls.

Other sources of pollution are those carried from the urban and the rural areas of the watershed to the surface water system by means of direct runoff from the land and by interflow, that is, subsurface flow—both of which occur during and immediately after rainfall or snowmelt events—and by baseflow, that is, groundwater discharge, between such events. Most of the direct runoff from urban areas enters the surface water system through the storm sewer outfalls located along the major stream system with the remaining direct runoff entering the streams via combined sewers, open storm water channels, or as sheet flow—that is, overland flow not occurring in well defined channels. Direct runoff from the rural portions of the watershed enters the surface water system through natural channels and as sheet flow. Water quality surveys reveal potentially troublesome concentrations of phosphorus, coliform bacteria, and biochemical oxygen demand in runoff from the rural and urban areas. In addition, the sediment yield from the watershed is very high—estimated at almost 100 tons per square mile per year—reflecting the urbanizing nature of the basin.

Measures Already Underway or Planned to Resolve Pollution Problems

Substantial efforts have already been initiated to resolve some of the pollution problems in the Menomonee River watershed. These efforts are briefly discussed below and related to the pollution sources described above.

Four municipal sewage treatment facilities exist in the watershed as of early 1976—the Village of Germantown Old Village plant, the Village of Menomonee Falls Pilgrim Road and Lilly Road plants, and the Village of Butler overflow-chlorination facility. The adopted regional sanitary sewerage system plan for southeastern Wisconsin[2] recommends the eventual abandonment of the four remaining municipal sewage treatment plants. This is proposed to be accomplished by connecting the sewer service areas presently served by each of the four plants to the Milwaukee-Metropolitan sewerage system with sewage treatment to be accomplished at the Jones Island or South Shore treatment plants located on the Lake Michigan shoreline. It is presently anticipated that all four remaining municipal sewage treatment plants will be permanently removed from service by 1981.

The 27-square-mile Milwaukee-Metropolitan area combined sewer service area, which includes a 10.7-square-mile area tributary to the Menomonee River, is the subject of the preliminary engineering study by a consulting firm directed at the abatement of combined sewer overflows. This study, which is scheduled for completion in 1977, builds upon previous work by the Regional Planning Commission under the Milwaukee River watershed planning program[3] and is to result in firm recommendations for construction of combined sewage conveyance and treatment facilities so as to abate this major source of pollution from the entire combined sewer service area.

Sewerage system flow relief devices other than combined sewer overflows, that is, crossovers, bypasses, relief pumping stations and portable pumping stations, will also be controlled by the Wisconsin Pollutant Discharge Elimination System. As described in Chapter X, Volume 1 of this report, the State Pollutant Discharge Elimination System was established by the Wis-

[2] *SEWRPC, Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, February 1974.*

[3] *SEWRPC, Planning Report No. 13, A Comprehensive Plan for the Milwaukee River Watershed, Volume 1, Inventory Findings and Forecasts, December 1970, Volume 2, Alternative Plans and Recommended Plan, October 1971.*

consin Legislature in direct response to the requirements of the Federal Water Pollution Control Act of 1972 and requires a permit for legal discharge of any pollutant into the waters of this State including groundwaters. More specifically, permits are required for crossovers, bypasses, relief pumping stations, and portable pumping stations, and the permits will eventually specify abatement requirements and a schedule of compliance setting forth dates by which various stages of requirements imposed by the permit shall be achieved. With respect to sanitary sewerage system flow relief devices, it is envisioned that the pollution discharge permit system will become the primary vehicle for abatement. The Wisconsin Pollutant Discharge Elimination System is also being used to determine the nature of industrial discharges to the surface water and groundwater systems and will be the primary vehicle by which the quantity and quality of those discharges will be controlled.

An unusual pollution problem in the watershed, and one for which some remedial actions have already been taken, is that caused by the former discharge of creosote to the Little Menomonee River by the Moss-American, Inc., railroad tie processing plant located near W. Brown Deer Road. As discussed in detail in Chapter VII, Volume 1 of this report, waste waters from the creosote operation are now discharged directly to the sanitary sewer system and the company has improved pretreatment facilities. The old, troublesome lagoons and filters on the plant site were eliminated; sludge deposits were removed from the Little Menomonee River in the immediate vicinity of the Moss-American facility; and the area adjacent to the stream was covered with clean fill. Envirex, Inc., of Milwaukee completed a federally funded demonstration project on a short reach of the Little Menomonee River providing technical and cost information as to a means for removing the creosote from the bottom muds of the Little Menomonee River downstream of the Moss-American plant.[4]

Onsite sewage disposal systems placed in soils poorly suited for effective operation of such systems are a cause of existing and potential pollution of private well water supplies. The adopted regional sanitary sewerage system plan contains recommendations for the ultimate resolution of this existing and potential water-supply pollution problem which affects about 14 percent of the watershed population, recommending the provision of sanitary sewer service to essentially all of those portions of the City of Brookfield, the Village of Menomonee Falls, the Village of Germantown, and the City of Mequon presently served by septic tank systems. The recommended provision of sanitary sewer service would eliminate the potential for pathogenic and aesthetic pollution from malfunctioning onsite disposal systems in the watershed.

On July 1, 1975, the Southeastern Wisconsin Regional Planning Commission initiated an areawide water quality planning and management program directed in part at resolution throughout the Region of another apparently important source of pollution in the Menomonee River watershed—diffuse or non-point source pollution from rural and urban areas.[5] The water quality management planning program for southeastern Wisconsin is intended to update, extend, and refine the previous water quality studies and plans completed by the Commission, and in so doing fully meet the requirements of Section 208 of the Federal Water Pollution Act.

Analytic Framework and Assumptions

The foregoing summary of surface and groundwater pollution problems and of pollution sources in the Menomonee River watershed, and the review of efforts underway or planned to abate or eliminate those sources and thereby mitigate the pollution problems, clearly indicates that progress is being made on the long-range pollution abatement program for the Menomonee River watershed. In consideration of the basic pollution abatement program already in progress, the water quality analyses under the Menomonee River watershed planning program—including the simulation model runs made in support of those analyses—were conducted within the following framework and based on the following overall assumptions summarized in Table 35.

Municipal Sewage Treatment Plants: The water quality analyses conducted under the Menomonee River watershed planning program accept as committed the eventual abandonment of the four remaining municipal sewage treatment plants in the watershed—the Village of Germantown Old Village plant, the Village of Menomonee Falls Pilgrim Road and Lilly Road plants, and the Village of Butler overflow-chlorination facility—as recommended in the adopted regional sanitary sewerage system plan. It was, however, deemed necessary to conduct simulation studies of the impact on existing water quality of the removal of these four plants from the watershed stream system. An analysis of the probable effect on surface water quality of removing the plants is necessary as a first step in determining if additional pollution abatement measures directed primarily at diffuse sources of pollution will be required in the Menomonee River watershed between now and the year 2000.

It is important to understand the degree to which the eventual abandonment of the four remaining municipal sewage treatment plants in the watershed is a "committed" decision. While there is agreement among the local, state, and federal units and agencies of government involved on the desirability of eventually abandoning the plants, the commitment extends beyond such agreement to the actual completed construction of relatively

[4] *As a result of the creosote pollution problem, Milwaukee County has filed suit against Moss-American, Inc., for $500,000 in damages. That suit was pending in federal court as of June 1976.*

[5] *Southeastern Wisconsin Regional Planning Commission, Study Design for the Areawide Water Quality Planning and Management Program for Southeastern Wisconsin: 1975-1977, August 1975.*

Table 35

POLLUTION ABATEMENT MEASURES UNDERWAY OR PLANNED IN THE MENOMONEE RIVER WATERSHED AND RELATED WATER QUALITY ANALYSES CONDUCTED UNDER THE MENOMONEE RIVER WATERSHED PLANNING PROGRAM

Pollution Source	Pollution Abatement Measure Underway or Planned	Related Water Quality Analysis Conducted Under the Menomonee River Watershed Planning Program
Four municipal sewage treatment plants discharging to the Menomonee River	To be permanently abandoned by about 1981	Conduct simulation studies to estimate the impact of removing the treatment plants and to determine if diffuse source pollution abatement measures should be considered
25 combined sewer overflows discharging to the Menomonee River downstream of Hawley Road under wet weather conditions	Preliminary engineering study underway to provide recommendations for abatement—scheduled for completion in late 1977	Water quality analysis not conducted in the combined sewer service area because the principal impact area is the estuary which is generally excluded from the watershed planning program and because of concurrent preliminary engineering study
102 sanitary sewer flow relief devices—crossovers, bypasses, relief pumping stations—discharging primarily to the Menomonee River during wet weather conditions	Wisconsin Pollutant Discharge Elimination System (WPDES) requires a permit for each device and a pollution abatement schedule. Watershed plan assumes gradual elimination of pollution from flow relief devices through WPDES	Determine the relative importance of pollution load from flow relief devices and consequences of elimination of those discharges
44 industrial point sources discharging primarily to the Menomonee River	WPDES requires a permit for each device and a pollution abatement schedule. Watershed plan assumes gradual elimination of pollution from industrial discharges	Pollution load assumed to be negligible
Creosote in bottom muds of most of the Little Menomonee River in Milwaukee County	Former point source of pollution has been eliminated and creosote has been removed from bottom muds of 0.75 miles of the Little Menomonee River	Develop alternative means of resolving the remaining creosote pollution problem
Onsite waste disposal systems used by approximately 14 percent of the watershed population	Adopted regional sanitary sewerage system plan recommends provision of sanitary sewer service to these areas. Watershed plan assumes implementation of recommendation to provide sanitary sewer service to presently unsewered urban areas and to planned urban development	Incorporate reduction of pollutant sources in modeling year 2000 plan conditions
Surface and groundwater discharge from urban and rural lands	SEWRPC preparing a "Section 208" areawide water quality planning and managment program	Conduct simulation studies to project the likely impact—if any—of planned incremental urban development and to determine if alternative diffuse source pollution abatement measures should be considered. Evaluate the effect of diffuse source pollution control measures applied to urban and rural lands

Source: SEWRPC.

long segments of the major trunk sewers that will eventually provide the necessary hydraulic connections between the tributary source areas of the four municipal sewage treatment plants and the Jones Island and South Shore sewage treatment facilities of the Milwaukee Metropolitan sewerage system located on the Lake Michigan shoreline.

An example of a major trunk sewer segment that has already been constructed is the 30- to 60-inch diameter, 2.9-mile-long segment of trunk sewer lying along the Menomonee River between Pilgrim Road and the Waukesha-Milwaukee County line in the Village of Menomonee Falls, designed to convey sanitary sewage from the two existing sewage treatment plants in the Village to the Waukesha-Milwaukee County line for subsequent conveyance to the Jones Island-South Shore treatment facilities. Another example of a major trunk sewer segment that has already been constructed to permit the eventual abandonment of municipal sewage treatment plants in the Menomonee River watershed is the 72-inch-diameter, 6.0-mile-long segment of trunk sewer along the Menomonee River in Milwaukee County between W. Burleigh Street in the City of Wauwatosa and W. Good Hope Road in the City of Milwaukee. Upon completion of other connecting trunk sewer segments, this major trunk sewer will receive sanitary sewage presently treated at the four municipal sewage treatment plants in the watershed and convey it through the middle portions of the watershed for eventual treatment at the Milwaukee-Metropolitan Sewerage Commission treatment facilities.

The abandonment of the four treatment facilities is thus committed in terms of an agreed-upon plan and program by the implementing governmental units and agencies; in terms of trunk sewers that have actually been constructed; and in terms of capital that has already been expended. Considering the degree to which the abandonment of the sewage treatment plants is committed in terms of plans developed, facilities constructed, and funds expended, continued efforts to carry out this committed decision are far more likely to be cost-effective than the expenditure of funds on the improvement of the existing treatment facilities and, thereby, not utilizing or fully utilizing the capacity of the trunk sewers that have been constructed.

Combined Sewer Overflows: The water quality analyses and related modeling efforts did not address the impact of combined sewer overflows nor the ultimate resolution of the combined sewer overflow problem on the 5.14 mile portion of the Menomonee River downstream of Hawley Road. The 10.7-square-mile combined sewer service area in the Menomonee River watershed was omitted from the water quality analyses for two reasons. First, the 2.22-mile-long portion of the Menomonee River downstream of The Falk Corporation dam is part of the Milwaukee Harbor estuary and, as explained in Chapter I, Volume 1 of this report, the watershed study was not intended to deal with the complex water quality problems of the estuary. This approach to the estuary area was adopted at the outset of the Menomonee River watershed planning program because the Menomonee River-Milwaukee River-Kinnickinnic River estuary constitutes an integral hydraulic-water quality system that must be analyzed in its totality. The second reason for not conducting water quality analyses along the Menomonee River downstream of Hawley Road was a desire not to duplicate the planning and engineering studies already underway by the Milwaukee-Metropolitan Sewerage Commissions and their consultants. These studies are intended to build on the previous work by the Regional Planning Commission under the Milwaukee River watershed planning program and to provide firm recommendations for construction of sewage conveyance and treatment facilities for the abatement of pollution from the entire combined sewer service area.

Other Flow Relief Devices: The water quality plan element of the Menomonee River watershed plan does not include an explicit analysis of alternative ways of eliminating sanitary sewerage system flow relief devices, that is, crossovers, bypasses, relief pumping stations, and portable pumping stations. The Menomonee River watershed plan accepts, as committed, the ultimate elimination of discharge from those devices as recommended in the adopted regional sanitary sewerage system plan and as intended by the Wisconsin Pollutant Discharge Elimination System as described in Chapter X, Volume 1 of this report.

Inasmuch as the 102 flow relief devices in the watershed are located throughout most of the basin and discharge to all the major streams, an analysis of the relative pollutant loads from this source, as opposed to other point and non-point sources such as municipal sewage treatment plants and runoff from the land surface, was conducted in order to determine the likely consequences of eliminating the flow relief devices.

Industrial Discharges: The water quality management plan element of the Menomonee River watershed plan also assumes that industrial discharges to the surface water system of the watershed will come under control as a result of the Wisconsin Pollutant Discharge Elimination System. As described in Chapter VII, Volume 1 of this report, a total of 44 industrial discharges were known to exist in the watershed as of May 1975.

These industrial discharges were assumed to have a very small impact on surface water quality of the Menomonee River watershed relative to the impact of discharges from municipal sewage treatment plants, flow from the land surface, and groundwater discharge for three reasons. First, about one-half of the discharges consist only of cooling water. Inasmuch as a review of watershed water quality data from a variety of sources revealed no thermal pollution problems, small discharges of cooling water at scattered locations around the basin may be reasonably assumed to have no significant impact on instream water temperatures. Secondly, about half of the industrial discharges are located one-half mile or more from the major receiving stream which provides an opportunity for dilution or assimilation of potentially troublesome substances that may be present prior to their entry to the major stream system of the watershed. Third, the treatment facility at the Milwaukee Road maintenance complex in the Menomonee River industrial valley at the 35th Street viaduct, which had been earlier identified as another potentially troublesome industrial source, discharges to the Menomonee River about one-half mile upstream of the estuary. Since it has the potential to affect only the estuary and since the watershed study was intended to exclude water quality aspects of the estuary, as discussed in Chapter I, Volume 1 of this report, the Milwaukee Road maintenance complex's discharge is of no practical concern to the Menomonee River watershed planning program.

Creosote in the Little Menomonee River: Development of the water quality management plan element for the Menomonee River watershed planning program includes an analysis of alternative means of resolving the residual creosote pollution problem that exists along portions of the Little Menomonee River in Milwaukee County. Although wastewater containing creosote is now discharged to the sanitary sewer system rather than the Menomonee River, although the Moss-American, Inc., has performed a general cleanup operation on its property at Brown Deer Road, and although creosote has been removed from the bottom muds of a 0.75-mile-long reach of the Little Menomonee River downstream of Brown Deer Road, a serious residual creosote pollution problem still exists within the bottom muds of portions of the Little Menomonee River downstream of that location. Inasmuch as no efforts were underway as of 1976 to remove the creosote that remains, it was incumbent upon the Menomonee River watershed planning program to examine alternative ways of removing creosote and to make appropriate recommendations.

Onsite Waste Disposal Systems: Analyses conducted in support of the water quality management plan element of the Menomonee River watershed plan assume that the localized pollution problems caused by the concurrent use of shallow, private wells and onsite waste disposal systems will, between now and the plan year 2000, be resolved through implementation of the recommendations in the adopted regional sanitary sewerage system plan which specify that presently unsewered urban development as well as planned urban development, should be provided with sanitary sewer service. Simulation modeling of year 2000 plan conditions incorporates a reduction in concentration of pollutants in groundwater discharge to reflect the decreased pollution load associated with elimination of onsite waste disposal systems.

Wash-Off from the Land Surface: The water quality analyses and water quality simulation modeling conducted under the watershed plan examined the possible adverse effects of planned incremental urban development on surface water quality. The recommended land use plan element for the watershed anticipates a 21 percent increase in urban land use. Such a shift from rural to urban land uses may have an adverse effect on surface water quality. Simulation model runs were conducted to compare expected surface water quality characteristics under existing conditions to year 2000 plan conditions in order to determine the likely impact—if any—of planned incremental urbanization on water quality conditions. Additional analyses were carried out to evaluate the effect of land management measures intended to control diffuse source pollution in both urban and rural portions of the watershed.

ALTERNATIVE MEASURES FOR RESOLVING THE CREOSOTE PROBLEM IN THE LITTLE MENOMONEE RIVER

The creosote that remains in the bottom muds of portions of the Little Menomonee River in Milwaukee County downstream of W. Brown Deer Road constitutes a potential hazard to people who may wade into the stream or otherwise come in contact with the stream, particularly with the bottom muds. The creosote is unevenly distributed in the bottom muds both horizontally and vertically and has apparently penetrated the bottom muds to a maximum depth of 2 to 3.5 feet.[6] The creosote has the potential to cause serious injury to humans as evidenced by the first degree skin burns and abdominal pain incurred by a participant in the June 5, 1971, cleanup of the Little Menomonee River[7] and by the chemical burns incurred by personnel involved in the 1973 U.S. EPA-sponsored demonstration project on a portion of the Little Menomonee River.[8] Creosote also has the potential to be toxic to aquatic flora and fauna or to render organisms more susceptible to disease, as revealed by the degraded condition of aquatic flora and fauna in the Little Menomonee River and by laboratory tests conducted in conjunction with the 1973 demonstration project. Accordingly, the Menomonee River watershed planning program included, in addition to the "no action" alternative, the development and examination of three alternative measures for abating the creosote problem that remains in portions of the Little Menomonee River within Milwaukee County.[9]

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[6] *"Demonstration of Removal and Treatment of Contaminated River Bottom Muds-Phase II," Environmental Sciences Division, Envirex, Inc., EPA contract 68-03-0182; in publication as of 1976.*

[7] *As described by Citizens for Menomonee River Restoration, Inc., in "The Creosote Problem in the Little Menomonee River," no date, 67 pages.*

[8] *"Demonstration of Removal and Treatment of Contaminated River Bottom Muds—Phase II," Envirex.*

[9] *The 1973 demonstration project was preceded by a 1972 feasibility study in which Envirex, Inc., of Milwaukee, Wisconsin, and Industrial Biotest Company of Chicago, Illinois, each tested creosote removal procedures in different approximately 500-foot-long reaches of the Little Menomonee River in the vicinity of Bradley Road. As a result of these tests, Envirex, Inc., was selected for the 1973 demonstration project.*

Identification of the Problem Reach

Based on field reconnaissance, sampling, and laboratory analyses conducted in the summer of 1971 by the Citizens for Menomonee River Restoration, Inc., and by personnel of Limnetics, Inc., creosote was found to exist in the bottom muds of the 3.75 mile reach of the Little Menomonee River shown on Map 46, extending from the Moss-American, Inc., plant at W. Brown Deer Road downstream to a point about 2,000 feet downstream of the Fond du Lac Freeway (USH 145). The 1971 field studies were limited to the reach between W. Brown Deer Road and the location at which the River cleanup participant incurred injury. Therefore, while the 1971 field studies indicated that creosote was, at that time, present in the bottom muds of the Little Menomonee River between W. Brown Deer Road and the Fond du Lac Freeway, no information from those studies indicated whether or not creosote was located in the bottom muds of the Little Menomonee River a significant distance downstream of the Fond du Lac Freeway or whether or not it would be found in the Menomonee River downstream of its confluence of the Little Menomonee River.

The 1973 demonstration project, which removed the creosote from the bottom muds of the 0.75-mile-long reach of Little Menomonee River downstream of W. Brown Deer Road, resulted in a recommendation that cleanup operations be extended further downstream along the Little Menomonee River to W. Good Hope Road. This recommendation was based on observation of significant amounts of creosote in the bottom muds of the Little Menomonee River in that reach. It should be noted, however, that the 1973 project did not include a detailed field reconnaissance of the Little Menomonee River downstream of W. Good Hope Road and, therefore, did not provide sufficient information to determine if potentially troublesome quantities of creosote are present in the Little Menomonee River downstream of that point.[10]

The Commission staff, therefore, inspected the Little Menomonee River and immediate environs throughout the reach from W. Brown Deer Road to the confluence with the Menomonee River together with a short reach of the Menomonee River downstream of that location in May of 1976. This field inspection included examining the River bank for creosote or evidence of its adverse effects, probing the bottom muds to detect the presence of creosote, and searching for evidence of creosote in the water as evidenced by oily sheen on the water surface. This inspection revealed evidence of the presence of creosote in and near the Little Menomonee River as far downstream as W. Fond du Lac Avenue. Little evidence of the presence of creosote was found along the Little Menomonee River downstream of that location or along the Menomonee River downstream of the confluence.

[10] "*Demonstration of Removal and Treatment of Contaminated River Bottom Muds—Phase II,*" *Envirex.*

Based on the above information, and as shown on Map 46, it was assumed that creosote in potentially troublesome quantities was present in the bottom muds of the Little Menomonee River throughout the 3.46-mile-long reach bounded at the upstream end by the downstream terminus of the 1973 cleanup project at River Mile 5.04 and bounded at the downstream end by W. Appleton Avenue at River Mile 1.58. It is possible that the downstream terminus of the reach containing potentially hazardous quantities of creosote may actually be located somewhere between W. Appleton Avenue and the confluence of the Little Menomonee River with the Menomonee River 1.58 miles downstream. Assuming that a river restoration operation is initiated, however, detailed field studies and supporting laboratory analyses conducted prior to the actual restoration work would more precisely identify the downstream terminus of the reach requiring cleanup measures. Such field studies and supporting laboratory analyses should be conducted throughout the project reach in order to identify possible sub-reaches within the project reach in which the creosote is either absent, or is present in quantities and at depths significantly less than those assumed for purposes of the development and comparison of alternatives. Careful field studies and supporting laboratory analyses may effect a substantial reduction in the overall cost of the creosote cleanup project. Such a refinement in identifying the length of the reach ultimately selected for removal or other treatment of the creosote will not affect the selection of the alternative measures described below, inasmuch as the relative cost of the measures is independent of the length of stream to which they are applied.

It is important to note that the entire length of the problem reach is contained within Milwaukee County parklands. Because of this public ownership of the riverine area, the cost estimates for the alternative measures designed to resolve the creosote problem do not include an element for either land acquisition or acquisition of an access easement. Furthermore, public ownership of the lands by one governmental unit—Milwaukee County—should enhance the likelihood of rapid implementation of a uniform, coordinated cleanup measure.

Alternative 1—No Action

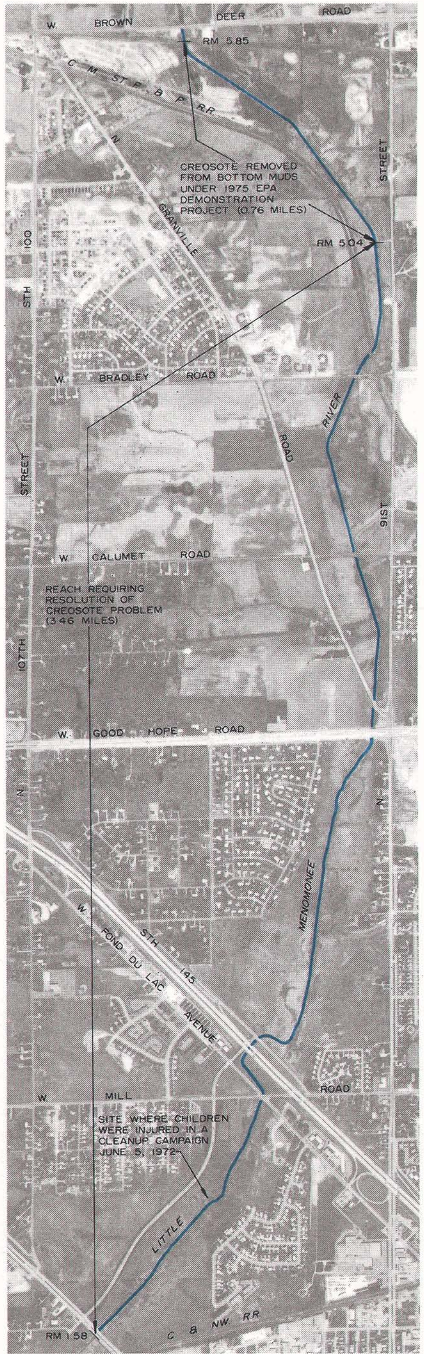
Under this alternative, no action would be taken to reduce the residual creosote pollution in the Little Menomonee River other than to maintain the current practice of posting the stream so as to clearly indicate the threat posed by the creosote in the stream. Accordingly, and in contrast with the other three alternative courses of action, there would be no monetary cost associated with this alternative.

Inasmuch as creosote is insoluble in and more dense than water and tends to agglomerate into cohesive masses, it is unlikely that natural physical processes such as the flushing action of the Little Menomonee River, even under high velocity flow conditions during flood events, will quickly remove the creosote from the bottom muds of the Little Menomonee River. It is also unlikely that

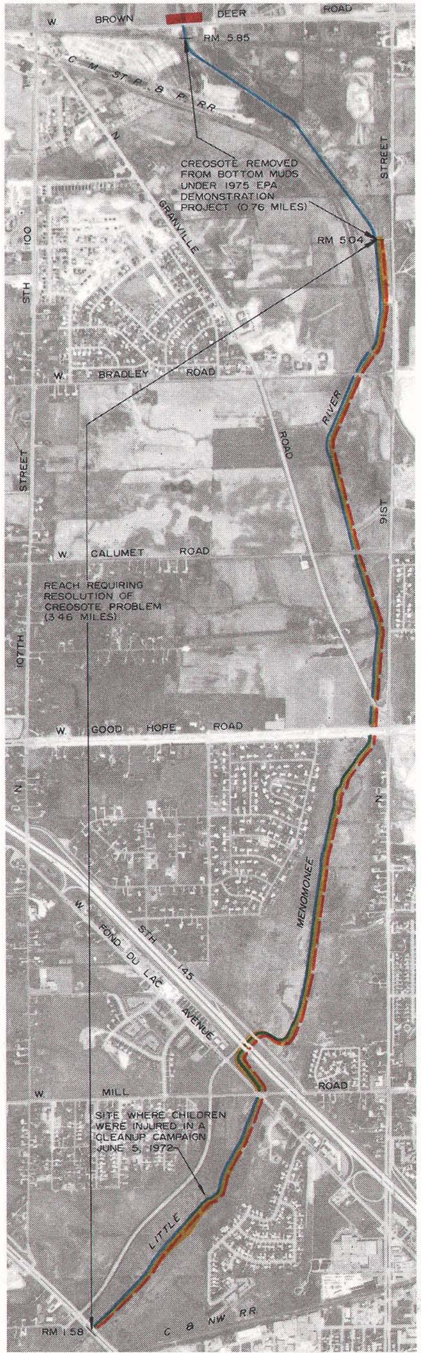
Map 46

ALTERNATIVE APPROACHES TO THE RESIDUAL CREOSOTE PROBLEM IN THE LITTLE MENOMONEE RIVER

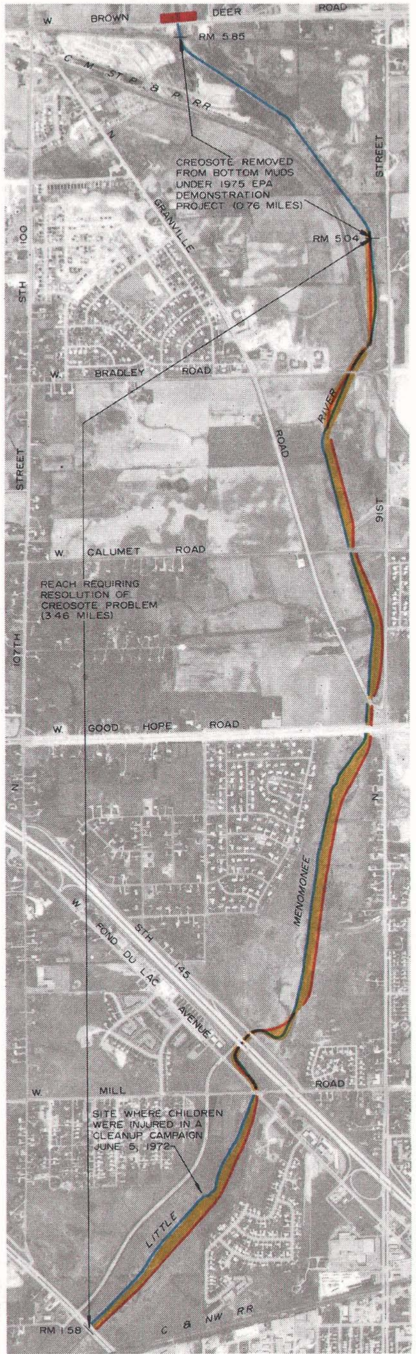
Alternative 2
Minimum Disturbance Demonstration Project Approach



Alternative 3
Replace Channel Bottom Material

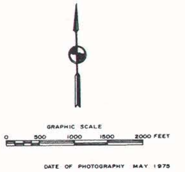


Alternative 4
Excavate New Channel and Fill Existing Channel



LEGEND

- EXISTING CHANNEL
- TEMPORARY DAM REQUIRED FOR ALTERNATIVES 3 AND 4
- TEMPORARY ACCESS ROAD REQUIRED FOR ALTERNATIVE 3
- NEW CHANNEL ALIGNMENT UNDER ALTERNATIVE 4
- AREA REQUIRING LANDSCAPING



In addition to Alternative 1—"no action" alternative—three alternative measures were developed and examined for resolution of the residual creosote pollution problem along that reach of the Little Menomonee River below the Moss-American, Inc., railroad tie processing plant in Milwaukee County. Alternative 2—the minimum disturbance approach—would employ the same procedure used during the 1973 EPA-sponored demonstration project—in which the bottom sediments, creosote and water, are removed, run through a portable treatment plant and the water returned to the stream—and could be accomplished at a cost of about $603,000. Alternative 3, which would cost about $462,000, consists of removing the creosote-laden deposits for burial elsewhere followed by replacement with clean material. Alternative 4, which has an estimated cost of about $201,000, would entail excavating a new channel near and parallel to the affected reach of the Little Menomonee River with the excavated material being used to fill the existing channel thereby covering the troublesome creosote deposits. The watershed plan recommends implementation of the Alternative 4.

Source: SEWRPC.

bacterial decomposition or activity by other organisms will materially reduce the concentration of creosote in the bottom muds of the Little Menomonee River.

Inasmuch as the source of the creosote has been eliminated by Moss-American, Inc., it is reasonable to expect that there will be no increase in the amount of creosote present in the bottom muds of the affected reach. It is also reasonable to expect, that under this alternative the natural process of sedimentation may in time provide somewhat of a protective cover over the creosote-laden muds. Selection of the "no action" alternative, however, would mean that a substantial hazard may be expected to continue to exist for a relatively long time along the affected 3.46 mile reach of the Little Menomonee River.

Alternative 2—Minimum Disturbance (Demonstration Project) Approach

This alternative measure would employ the procedure used during the 1973 EPA-sponsored demonstration project which was intended, in part, to resolve the creosote problem with a minimum disturbance to the Little Menomonee River and its environs. Under this approach debris, brush, and overhanging limbs would first be removed from the immediate stream area so as to provide freedom of movement along the stream. Large objects would be hauled to a sanitary landfill for disposal and the remaining organic materials would be mulched and deposited on site. Floating booms would be positioned downstream of the reach in which operations were being conducted in order to capture creosote and other debris stirred up and released during the cleaning operation. The creosote and other debris which accumulates on the booms would be pumped from the upstream side of the booms to a tank truck for disposal at a sanitary landfill.

Creosote removal would be accomplished with the facilities and treatment units shown schematically in Figure 20. An instream "sweeper" would remove a mud-creosote-water slurry from the stream and pump it to a presettling tank. The mud-creosote sludge extracted in the presettling tank would be pumped to a tank trailer truck for disposal in a sanitary landfill and the remaining mud-creosote-water mixture would be pumped to a reaction tank where a coagulant would be added to encourage sedimentation of colloidal and suspended materials. This step in the process would be followed by final clarification, with the mud-creosote sludge again going to a tank trailer for disposal at a sanitary landfill and the remaining water-creosote mixture being pumped through a series of trailer mounted mixed media and activated carbon filters after which the creosote-free effluent would be returned to the river.

The "minimum disturbance" approach is so-called since most of the equipment used is positioned on a nearby street or highway and is connected to the "sweeper" unit by a flexible hose extending down to the River. There is, therefore, no need to enter the riverine area with heavy equipment. Disturbance to the land immediately adjacent to the stream can be minimized. Upon completion of the cleaning operations, any river bank area that has been disturbed would be restored by grading and seeding.

Tests conducted during the recently completed demonstration project indicate that this approach may be expected to produce an approximately 75 percent reduction in the quantity of creosote in the bottom muds and that the resulting concentration would be less than 5,000 milligrams of creosote per kilogram of mud. The latter was the "safe" standard established based on laboratory toxicity and skin irritation tests.

The cost of Alternative 2—the Minimum Disturbance Approach—is estimated at $33 per foot, based on costs incurred during demonstration of project. The capital cost of the equipment is not reflected in this cost inasmuch as the U.S. Environmental Protection Agency was to maintain the equipment on stand-by basis for use in emergency spills of hazardous materials. If this alternative were applied to the 3.46-mile-long affected reach, the cost would total about $603,000. Utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at $38,250. Table 36 includes a brief description of Alternative 2 and facilitates comparison of the costs and other features of this and the other three alternatives.

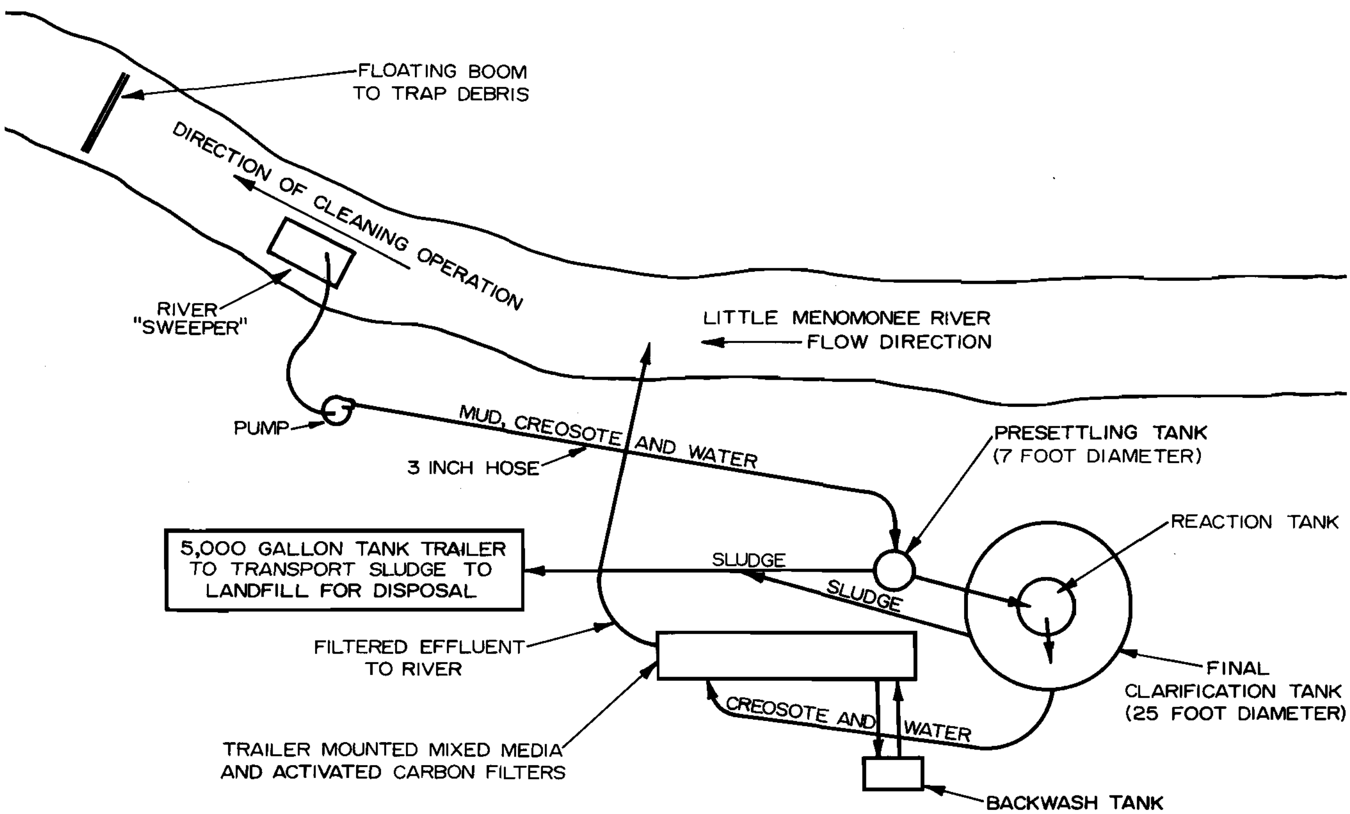
Alternative 3—Replacement of Channel Bottom Material

Under this alternative, the creosote-laden bottom muds would be removed from the problem reach of the Little Menomonee River and be replaced with material intended to maintain a stable channel and to provide a media for desirable aquatic flora and fauna. The work would be initiated by selecting a reach immediately downstream of the downstream terminus of the reach cleaned during the completed demonstration project. A floating boom or series of booms would be established at the downstream end of the reach in order to capture creosote and other debris stirred up and released during the cleaning operation with the accumulated creosote and other debris being pumped from the upstream side of the booms to a tank truck for disposal at a sanitary landfill.

A temporary dam would be constructed on the Little Menomonee River at Brown Deer Road so as to significantly reduce the flow in the Little Menomonee River through the reach being cleaned, thereby expediting the excavation operation. The River flow above W. Brown Deer Road would be temporarily stored behind the dam on Milwaukee County park lands located along the Little Menomonee River between W. Brown Deer Road and the Milwaukee-Ozaukee County line. Assuming average river flows similar to those which occur during the fourth month period from June 1 through September 30, there would be sufficient storage available immediately upstream of W. Brown Deer Road to temporarily impound approximately two months of flow.

Figure 20

SYSTEM USED IN 1973 TO REMOVE CREOSOTE FROM THE BOTTOM MUDS OF A 0.75 MILE REACH OF THE LITTLE MENOMONEE RIVER



Source: Envirex and SEWRPC.

Trucks would be used to haul gravel into the riverine areas so as to form a temporary roadway along one side of the stream as shown on Map 46 and on Figure 21. The temporary roadway would provide access for front-end loader or other similar equipment which would remove the creosote-laden bottom muds from the Little Menomonee River to a depth of about three feet. The roadway would also provide access for trucks to haul the material from the riverine area to a sanitary landfill for disposal. The quantity of sand and gravel used to construct the temporary roadway would be sufficient for roadway purposes and would also be approximately equal to the volume of material that would be excavated from the Little Menomonee River.

After bottom muds had been excavated from the stream, the front-end loader or other similar earth-moving equipment would be used to push the sand and gravel forming the temporary roadway into the river. This would eliminate the temporary roadway, replace the excavated material so as to stabilize the channel, and provide a suitable base for establishment of a desirable fresh water aquatic flora and fauna.

The disturbed area along the stream would then be restored through seeding and planting of native Wisconsin grasses, bushes, and trees typical of floodland areas. After completing restoration of a portion of the problem reach, the temporary storage reservoir at Brown Deer Road would be emptied, the dam would be closed, a new reach immediately downstream of the restored reach would be selected, and the above process would be repeated.

Alternative 3—replacement of channel bottom material—would result in removal of most of the creosote contained within the bottom muds of the problem reach inasmuch as the excavation would be carried down to three feet, the approximate maximum depth to which the creosote has penetrated the bottom muds. Furthermore, hazards that might be associated with the remaining creosote would be minimal in that the creosote would be covered by several feet of "clean" sand and gravel. The new sand and gravel bottom would replace the excavated material and help to stabilize the disturbed channel and, equally important, would serve as the basis for the establishment—by natural sedimentation and biological processes—of a substrate suitable for the

Table 36

ALTERNATIVE MEASURES FOR RESOLVING THE CREOSOTE PROBLEM IN THE LITTLE MENOMONEE RIVER

Alternative[a]			Technically Feasible?	Cost (In Dollars)		Expected Results
Number	Name	Description		Capital	Annual	
1	No action	No attempt to remove creosote or otherwise reduce the potential danger associated with it other than to continue posting the stream to warn of the hazard that exists	Yes	0	0	No change in the quantity of creosote present. Threat to people and to aquatic flora and fauna may be slightly mitigated by flushing during flood events and by sediment deposition
2	Minimum Disturbance (Demonstration Project) Approach	Remove large debris and overhanging branches and limbs and establish debris booms. Pump mud-creosote-water mixture from stream bottom, extract mud and creosote, filter water and return it to the stream. Restore disturbed area along stream	Yes	602,900[b]	38,250[b]	Significant reduction in creosote quantity and hazard to people and aquatic flora and fauna
3	Replacement of Channel Bottom Material	Construct temporary dam at Brown Deer Road, establish debris booms, construct temporary roadway, excavate and dispose of creosote-laden channel bottom mud, push temporary road material into stream, and landscape disturbed area along stream	Yes	462,200	29,320	Significant reduction in creosote quantity and hazard to people and aquatic flora and fauna
4	Excavate New Channel and Fill Existing Channel	Construct temporary dam at Brown Deer Road, establish debris booms, excavate new parallel channel, fill existing channel, and landscape disturbed area	Yes	201,000	12,740	Significant exposure reduction in creosote exposure and hazard to people and aquatic flora and fauna

[a] *The problem reach is the 3.46-mile-long portion of the Little Menomonee River in Milwaukee County extending from River Mile 5.04—approximately 0.4 mile north of Bradley Road—downstream to Appleton Avenue at River Mile 1.58.*

[b] *Excludes capital cost of equipment.*

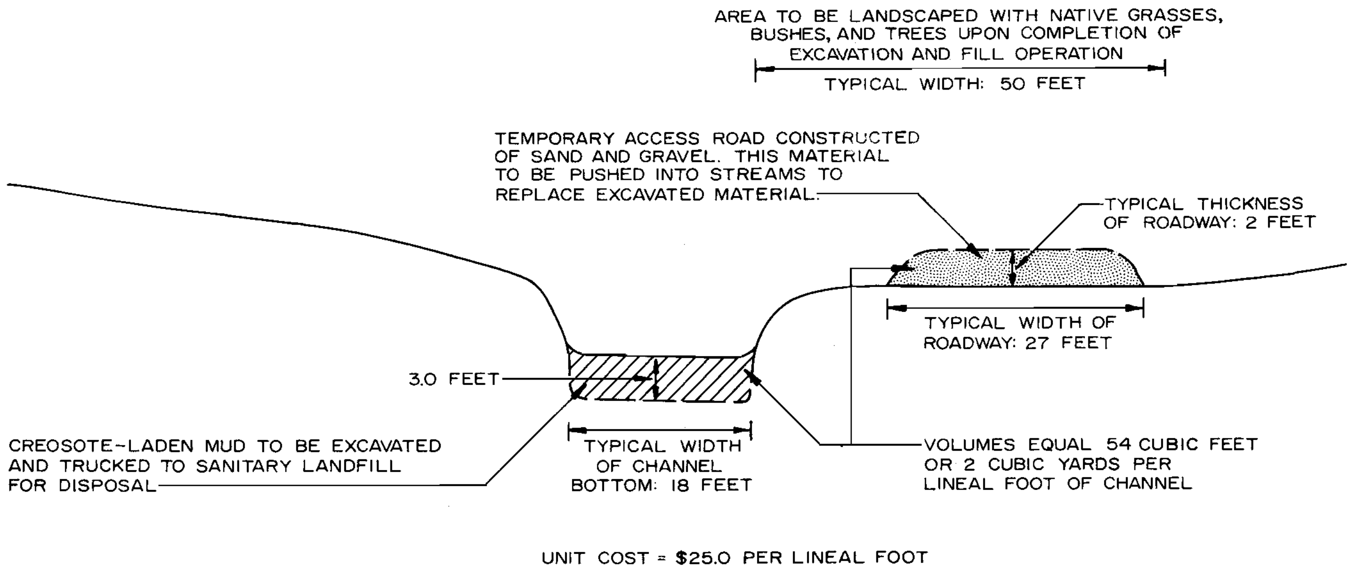
Source: SEWRPC.

growth of desirable aquatic flora and fauna. Although a 50 foot strip contiguous with, and on one side of, the stream would be significantly disturbed during the restoration work, the proposed landscaping efforts upon completion of the excavation and filling operation would essentially restore the riverine area to its pre-project conditions.

The cost of Alternative 3 is estimated at $25 per foot based upon the costs of the following work elements: purchase and hauling of sand and gravel to construct the temporary access road, excavation of material from the stream and hauling it to a disposal point, pushing the temporary roadway into the stream bottom, and landscaping the riverine area. Assuming that Alternative 3—replacement of channel bottom material—were applied to the 3.46-mile-long affected reach of the Little Menomonee River, the cost of this alternative would be about $462,000. Utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the annual cost would be about $29,300. Table 36 includes a brief description of Alternative 3 and facilitates comparison of the costs and other features of this and the other three alternatives.

Figure 21

SCHEMATIC REPRESENTATION OF ALTERNATIVE MEASURE 3
FOR SOLUTION OF THE CREOSOTE PROBLEM IN THE LITTLE MENOMONEE RIVER



Source: SEWRPC.

Alternative 4—Excavate New Channel and Fill Existing Channel

The overall approach, under this alternative measure for resolving the residual creosote pollution problem, would be to excavate a new channel near and parallel to the affected reach of Little Menomonee River, with the excavated material being used to fill the existing channel thereby covering the creosote that is contained therein. More specifically, a temporary dam would be constructed at W. Brown Deer Road to form a temporary reservoir that would significantly reduce the flow in the existing channel of the Little Menomonee River so as to minimize the transport of material downstream in the Little Menomonee River and into the Menomonee River. Floating booms would be positioned downstream of the reach in which filling operations were to be conducted in order to capture the creosote and other debris stirred up and released during filling of the existing channel. The creosote and other debris accumulating on the booms would be pumped from the upstream side of the booms to a tank truck for disposal at a sanitary landfill.

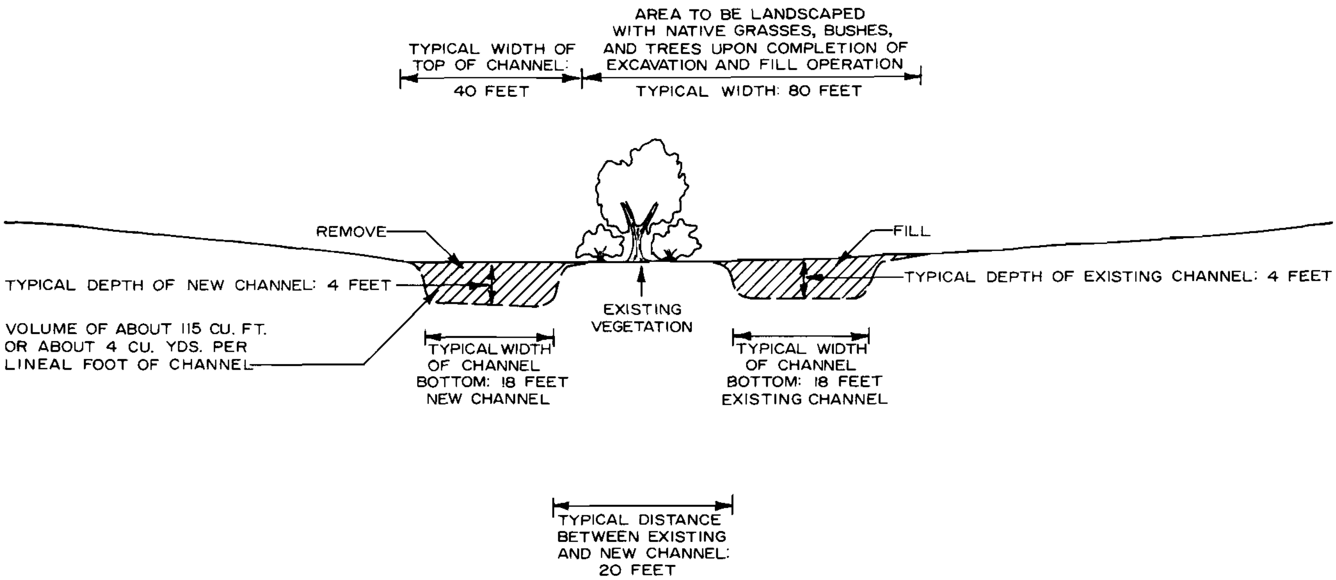
The new channel, similar in size to the existing channel, would be constructed parallel to and approximately 20 feet from the existing channel using a rubber-tired or tracked vehicle with the excavated material being used to fill in the existing channel. The excavation and filling process is illustrated schematically on Figure 22 and the approximate alignment of the new channel is shown on Map 46. The alignment of the new channel would be selected so as to be parallel and close to, or contained within, the narrow strip of vegetation that exists along the affected reach of the Little Menomonee River. This would be done partly to minimize the haul distance between the new and the old channel, partly to minimize the amount of area to be disturbed, and partly to retain the overall aesthetic quality of the riverine area—that is, the close proximity of the new stream alignment and the existing vegetal strip.

The existing problem reach includes crossings at the following seven locations: the Chicago, Milwaukee, St. Paul, and Pacific Railroad at River Mile 4.73, W. Bradley Road at River Mile 4.65, W. Calumet Road at River Mile 4.13, CTH F at River Mile 3.70, W. Good Hope Road at River Mile 3.62, W. Fond du Lac Avenue at River Mile 2.58, and W. Mill Road at River Mile 2.41. At each of these locations the stream alignment would be retained so as to permit continued use of the existing waterway openings and, accordingly, the restoration would include a localized cleanup of the creosote through and immediately upstream and downstream of the water openings.[11] After filling the existing channel, the Little Menomonee River would be routed into the

[11] *The jurisdictional highway system plan for Milwaukee County recommends the reconstruction of W. Mill Road to provide additional traffic capacity. In implementing that recommendation, Milwaukee County proposes to move the W. Mill Road crossing of the Little Menomonee River approximately 0.05 mile west of the present location in order to eliminate the existing complex intersection of W. Mill Road and W. Fond du Lac Avenue. That planned relocation of the Little Menomonee River could be done in conjunction with Alternative 4.*

Figure 22

SCHEMATIC REPRESENTATION OF ALTERNATIVE MEASURE 4
FOR SOLUTION OF THE CREOSOTE PROBLEM IN THE LITTLE MENOMONEE RIVER



Source: SEWRPC.

UNIT COST = $11.0 PER LINEAL FOOT

new channel. Disturbed areas between the new and old channel, as well as the old channel itself, would be restored using native Wisconsin grasses, bushes, and trees typical of riverine areas.

Inasmuch as the creosote-laden bottom muds of the problem reach of the Little Menomonee River would, under this alternative, be covered by up to approximately four feet of clean fill material, the associated hazards would in effect be eliminated. This alternative would be aesthetically acceptable: the new channel alignment generally would coincide with the narrow strip of shrubs and trees that exists along the problem reach and the disturbed area, as well as the filled channel, would be landscaped subsequent to completion of the work.

Even though creosote is insoluble in water, there is a remote possibility that the creosote which would remain along the Little Menomonee River could contaminate the local groundwater. However, inasmuch as this urban area along the Little Menomonee River is served by public water supply, it is unlikely that contamination of the groundwater supply would pose any significant hazard to the population in the area.

The costs of Alternative 4—excavate new channel and fill existing channel—are estimated at $11 per foot which consists primarily of the cost of excavating the new channel, filling the old channel, and subsequent necessary landscaping. Assuming that the alternative would be implemented, the capital cost of applying the procedure to the 3.46-mile-long problem reach would be about $201,000. Using an annual interest rate of 6 percent and a project life and amortization period of 50 years, the average annual cost is estimated at about $12,700. Table 36 includes a brief description of Alternative 4 and facilitates comparison of the costs and other features of this and the three other alternatives.

Recommended Measure for Resolution of the Creosote Problem

The no-action alternative was rejected since the presence of large quantities of creosote in the bottom muds of a 3.46-mile-long reach of the Little Menomonee River in an urban and urbanizing area constitutes a potentially serious threat to the health and well being of the local population and of parkway users. This is particularly true of children who are naturally drawn to water and who, signs and verbal warnings notwithstanding, may not understand the danger of risking serious chemical burns and other health problems like those experienced by a participant in the June 1971 clean-up of Little Menomonee River. Furthermore, the creosote inhibits development of desirable fresh water flora and fauna and also absolutely prevents the recreational use of the stream. The presence of the creosote in its existing form prevents achievement of the established water use objectives and supporting standards which specify that this reach of the Little Menomonee River shall be suitable for recreational use and fish and aquatic life.

Two measures are available for removing most of the creosote from the bottom muds of the problem reach of the Little Menomonee River: Alternative 2, the minimum disturbance (demonstration project) approach, which would have a capital cost of $602,900 and Alternative 3, the replacement of channel bottom material approach, which would have a capital cost of $462,200. Alternative 4, which would consist of excavating a new channel and filling the existing channel, would not remove the creosote from the Little Menomonee River but would cover it with a protective layer of up to four feet of fill and would have a capital cost of $201,000.

Alternatives 2, 3, and 4 each would substantially reduce the hazard associated with the creosote in the Little Menomonee River. Inasmuch as there is no substantial difference in the expected results, either in terms of extent of the reduction of the hazard or in terms of the aesthetic impact of the restoration work, a choice between these three alternatives can be made strictly on a cost basis. It is, therefore, recommended that the creosote problem in the Little Menomonee River within Milwaukee County be resolved by excavating a new channel and filling the existing channel at a capital cost of about $201,000.

WATER QUALITY CONSEQUENCES OF ABANDONMENT OF MUNICIPAL SEWAGE TREATMENT PLANTS, IMPLEMENTATION OF LAND USE PLAN, AND APPLICATION OF LAND MANAGEMENT MEASURES FOR POLLUTION CONTROL

As noted in Chapter VIII, Volume 1 of this report, the principal purpose of developing and calibrating the water resource simulation model under the Menomonee River Watershed Study was to provide a tool for quantifying watershed hydrologic, hydraulic, and water quality characteristics under existing and various possible future development conditions and management measures within the watershed. The results of applying the water quality submodel to the watershed stream system are discussed in this and subsequent sections of this chapter. As described in Chapter VIII, Volume 1 of this report, the simulation modeling approach was determined to be the best practicable tool available to meet the needs of the Menomonee River Watershed Planning Program, providing a sound basis for quantitatively demonstrating the overall consequences of planned urban development and of implementing alternative water quality management measures directed at point and diffuse sources of pollution.

Overall Procedure

In using the water quality submodel to analyze the impact of the planned abandonment of the four remaining municipal sewage treatment plants, of the year 2000 land use plan on water quality conditions, and of alternative pollution abatement measures, the watershed land surface and stream system were represented as shown on Map 80 of Volume 1 for 1975 land use-floodland development conditions and as shown on Map 47 for year 2000 plan land use-floodland development conditions. The watershed land surface was represented by 56 hydrologic-water quality segments and the stream system was represented by 56 reaches.

As discussed in Chapter VIII, Volume 1 of this report, and as illustrated in Figure 64 of Volume 1, five categories of input data are required for the application of water quality submodel: 1) meteorological data, examples of which include wind movement, cloud cover, and radiation; 2) land data, an example of which is hourly runoff quantities from the pervious portion of a particular land segment type; 3) channel data, examples of which include reach length, fecal coliform die-off coefficient, and ammonia oxygenation coefficient; 4) diffuse source data, an example of which is the daily loading rate on the land surface of particular potential pollutants such as nutrients; and 5) point source data, examples of which include the rate and quality of municipal sewage treatment plant discharge to the stream system.

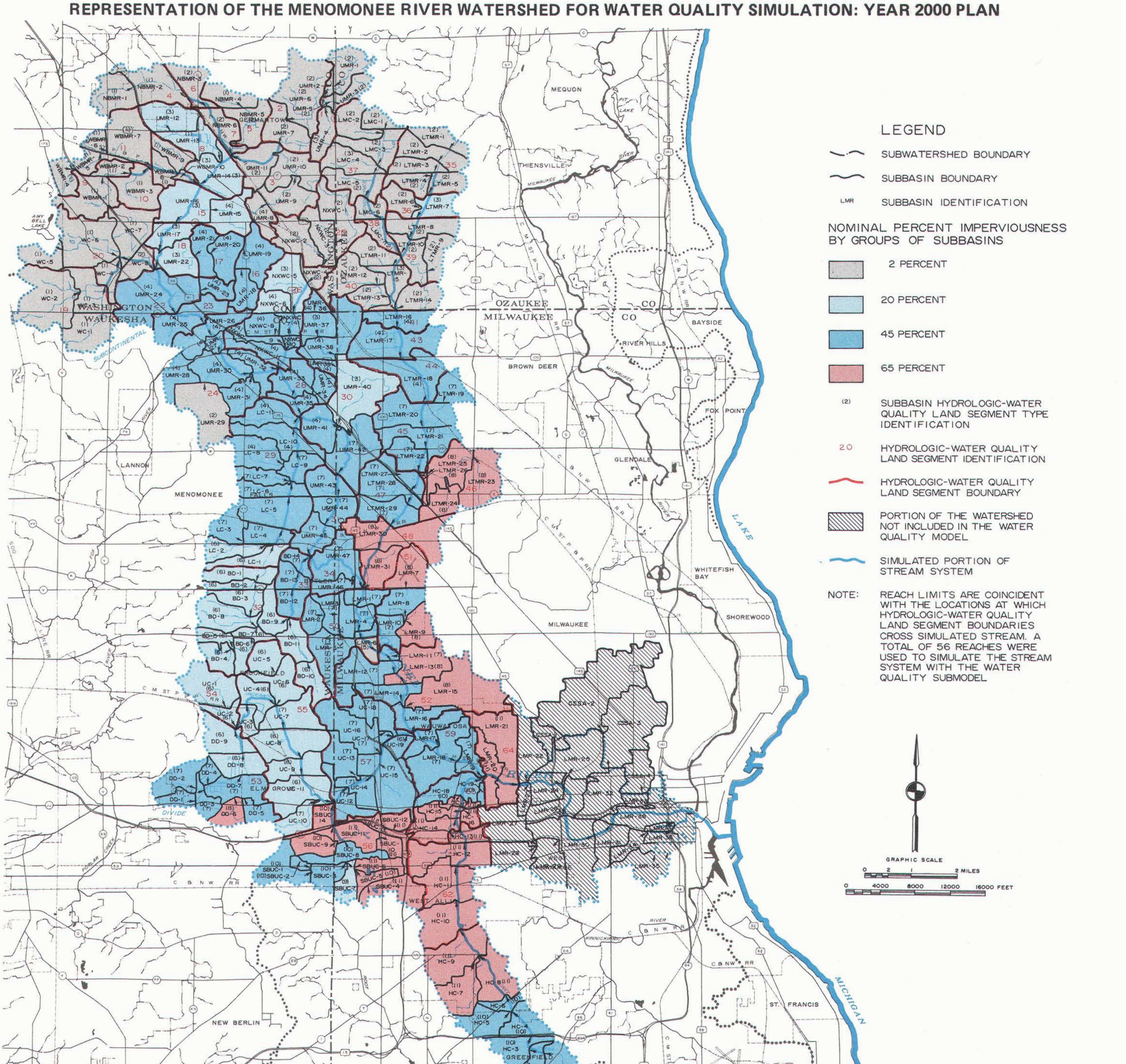
With regard to the sources of the five data types used for the water quality submodel, the meteorologic data were prepared early in the modeling process relying primarily on National Weather Service information; the land runoff data were developed using output from the hydrologic submodel; channel data were available, in part, from earlier runs of Hydraulic Submodel 1, and the remainder of the necessary channel data were obtained during calibration of the water quality submodel; and diffuse source and point source data sets were assembled based on values obtained during the calibration of the water quality submodel. Data base development and calibration of the model are described in detail in Chapter VIII, Volume 1 of this report.

A total of 12 locations were selected along the watershed stream system at which computed water quality levels and streamflows would be available from the model runs. As shown on Map 48, the 12 model output locations were distributed throughout the watershed stream system as follows: eight along the main stem of the Menomonee River between its confluence with the North Branch of the Menomonee River in the headwaters of the watershed and Hawley Road in the lower reaches of the watershed; two on the Little Menomonee River—one at the Ozaukee-Milwaukee County line and one immediately above the confluence of the Little Menomonee and Menomonee Rivers; one on Underwood Creek immediately above its confluence with the Menomonee River and one on Honey Creek immediately above its confluence with the Menomonee River.

A variety of objectives entered into the selection of model output locations including: 1) providing a reasonably uniform spatial distribution throughout the watershed stream system; 2) providing stations on all major streams; 3) providing stations at points where abrupt land use changes exist now—such as on the Menomonee River at the Washington-Waukesha County line—or where such changes are probable in the future—such as on the Little Menomonee River at the Ozaukee-Milwaukee County line; 4) providing stations relatively close to and upstream and downstream of the remaining four municipal sewage treatment plants; 5) using, where feasible, station locations corresponding to those used during the calibration of the water quality submodel;

Map 47

REPRESENTATION OF THE MENOMONEE RIVER WATERSHED FOR WATER QUALITY SIMULATION: YEAR 2000 PLAN

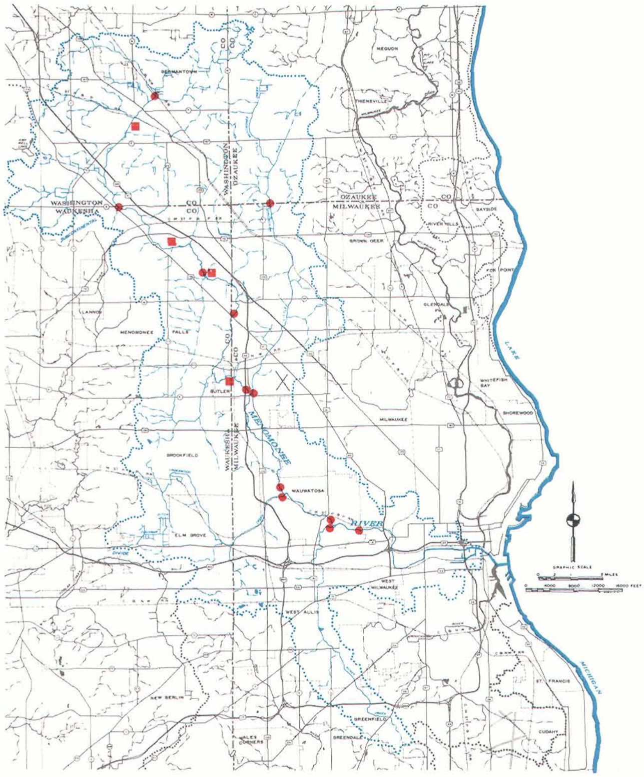


For purposes of water quality simulation modeling, under year 2000 planned land use conditions, the watershed was partitioned into 56 hydrologic-water quality land segments and the watershed stream system was subdivided into 56 reaches. The water quality-hydrologic land segments were the basis for simulating the transport of potential pollutants from the land surface to the stream system via direct runoff or groundwater flow. Each stream reach, as represented by a set of parameters, was used to simulate the accumulation of potential pollutants in the channel system and the resulting instream biochemical and advection processes. This representation of the watershed facilitated use of the water quality simulation model to determine the consequences of land use changes and land management measures on stream water quality.

Source: SEWRPC.

Map 48

LOCATIONS IN THE MENOMONEE RIVER WATERSHED FOR WHICH WATER QUALITY LEVELS WERE DETERMINED BY SIMULATION MODELING



LEGEND

● WATER QUALITY OUTPUT LOCATIONS

■ POINT SOURCE LOADS

A water quality simulation model was used to determine existing and probable future water quality levels at a total of 12 locations along the watershed stream system. The locations were selected so as to provide a representative spatial distribution of data on all major streams, data at locations where abrupt land use changes exist now or are anticipated in the future, and data at locations relatively close to and both upstream and downstream of the remaining municipal sewage treatment plants in the watershed.

Source: SEWRPC.

and 6) using, where feasible, some of the 55 locations at which floodflows and stages had been obtained under earlier model runs for floodland management purposes.

Low Flow Analysis for Existing Land Use Conditions With and Without Municipal Sewage Treatment Plants

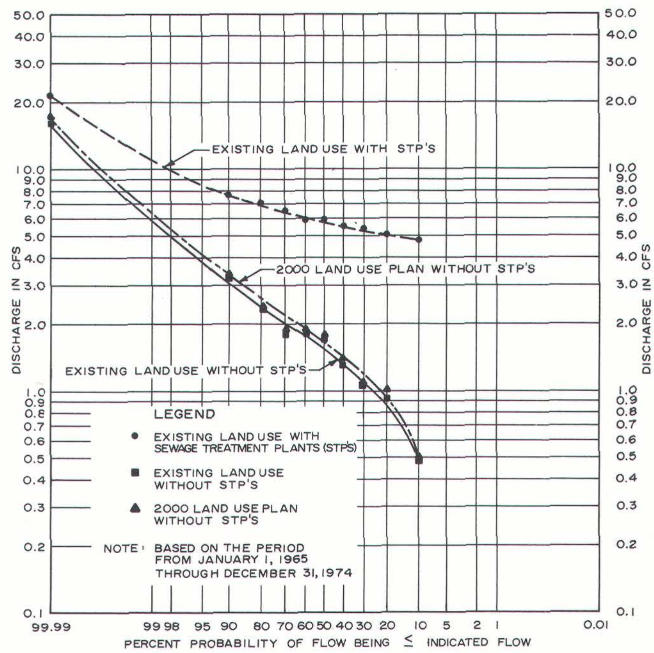
Procedure: The water use objectives adopted for the Menomonee River watershed surface waters prescribe compliance with supporting standards during the minimum seven-day mean low flow expected to occur at a given point on the watershed stream system once on the average of every 10 years. That is, for a given point on the stream system having an established water use objective, the stream water quality is to be such as to satisfy the supporting standards for all stream flows at or above the 7 day-10 year low flow.

Therefore, it was necessary to estimate the 7 day-10 year low flow at various locations throughout the watershed stream system in anticipation of conducting steady state model runs to determine instream water quality levels that would be expected to exist with and without the four municipal sewage treatment plants. The low flow analysis was extended to year 2000 plan conditions to determine if planned incremental urban development was likely to significantly affect extreme low flows and, therefore, the corresponding water quality.

The 10-year series of hourly streamflows developed with the water quality submodel for the period January 1, 1965, through December 31, 1974, was used to determine the 7 day-10 year low flow at 12 locations throughout the watershed stream system. Low flow discharge-frequency relations were determined for each of the selected locations under existing land use conditions with and without the flow contributions made by the four municipal sewage treatment plants and under year 2000 plan land use conditions without the four municipal sewage treatment plants. The existing land use condition analysis was made with and without the municipal sewage treatment plants because, during extremely low flow conditions, sewage treatment plant discharge constitutes a significant portion of the stream flow. Figure 23 shows the resulting three low flow discharge-frequency relationships for the Menomonee

Figure 23

SIMULATED 7-DAY LOW FLOW DISCHARGE-FREQUENCY RELATIONSHIPS FOR THE MENOMONEE RIVER AT HAWLEY ROAD



River at Hawley Road. Data used to prepare the discharge-frequency curve is similar to that developed for each of the 12 locations on the watershed stream system.

The resulting 7 day-10 year low flows for the three conditions at the 12 locations in the watershed are set forth in Table 37. Under existing land use conditions with the sewage treatment plants in operation, 7 day-10 year low flows are zero at 5 of the 12 locations in the watershed. This indicates that the upper reaches of the Menomonee River and the entire length of the Little Menomonee River, Underwood Creek, and Honey Creek may be expected to exhibit 7 day-10 year low flows of zero. Under existing land use conditions without the sewage treatment plants, the number of locations at which the 7 day-10 year low flow is zero increases to six with the additional station being located on the Menomonee River at the Washington-Waukesha County line. Under year 2000 plan land use conditions without sewage treatment plants the number of locations at which the 7 day-10 year low flow is zero would be unchanged relative to existing land use conditions without the sewage treatment plants.

The above low flow discharge-frequency analysis, as summarized in Table 37, indicates that it will be impossible to achieve the specified water quality standards under the specified low flow conditions at six of the 12 locations scattered about the watershed since the specified low flow at those locations will be zero. Stated another way, the standards supporting the water quality objectives cannot be achieved under year 2000 plan conditions for strictly hydrologic reasons—insufficient flow—for the Menomonee River in the Village of Germantown, and for the entire length of the Little Menomonee River, Underwood Creek, and Honey Creek.

In addition to providing the 7 day-10 year low stream flows needed to conduct the low flow water quality simulation, the low flow discharge-frequency relationships developed for the 12 locations in the watershed under existing land use conditions with and without sewage treatment plants and under year 2000 plan conditions reveal two significant hydrologic characteristics of the Menomonee River watershed with respect to water quality. First, removal of the four municipal sewage treatment plants from the watershed stream system under existing land use conditions will substan-

Table 37

7 DAY-10 YEAR LOW FLOWS IN THE MENOMONEE RIVER WATERSHED UNDER EXISTING AND FUTURE CONDITIONS

Location			7 Day-10 Year Discharge in cfs		
Stream	River Mile	Description	Existing (1975) Land Use Conditions With Municipal Sewage Treatment Plants	Existing (1975) Land Use Conditions Without Municipal Sewage Treatment Plants	Planned Year 2000 Land Use Conditions Without Municipal Sewage Treatment Plants
Menomonee River	5.14	Hawley Road	4.7	0.5	0.5
	6.33	Upstream of Confluence with Honey Creek	4.6	0.4	0.4
	8.33	Upstream of Confluence with Underwood Creek	4.6	0.4	0.4
	12.52	Upstream of Confluence with Little Menomonee River	4.5	0.3	0.3
	16.65	Waukesha-Milwaukee County Line	4.2	0.3	0.3
	19.07	Upstream of Lilly Creek	3.1	0.1	0.1
	23.47	Washington-Waukesha County Line	1.0	0.0	0.0
	27.30	Upstream of Confluence with North Branch of the Menomonee River	0.0	0.0	0.0
Little Menomonee River	0.0	At Menomonee River	0.0	0.0	0.0
	6.91	Ozaukee-Milwaukee County Line	0.0	0.0	0.0
Underwood Creek	0.0	At Menomonee River	0.0	0.0	0.0
Honey Creek	0.0	At Menomonee River	0.0	0.0	0.0

Source: SEWRPC.

tially reduce the magnitude of low flows along the main stem of the Menomonee River. For example, and as shown in Figure 23 and Table 37, the 7 day-10 year low flow on the Menomonee River at Hawley Road under existing land use conditions with the municipal sewage treatment plants is about 4.7 cfs [12] whereas removal of the municipal sewage treatment plants from the watershed flow system will reduce that 7 day-10 year low flow to 0.5 cfs—a 90 percent reduction. Similar large reductions in low flows may be expected along the entire length of the main stem of the Menomonee River. The water quality significance of this reduction in low flows is that, while elimination of discharges from municipal sewage treatment plants will reduce the load of potential pollutants such as oxygen demanding substances and nutrients, it also will result in a substantial reduction in the volume of water available in the stream to dilute and otherwise assimilate potential pollutants from other sources.

The second significant water quality-related consequence of the low flow discharge-frequency analysis conducted for the 12 locations throughout the watershed is that additional urbanization anticipated under the year 2000 plan should not cause a further reduction in low flows beyond those caused by removal of the sewage treatment plants. As illustrated in Figure 23, the 7-day low flow discharge-frequency relationship for existing land use conditions without sewage treatment plants and for year 2000 plan land use conditions without sewage treatment plants are essentially identical. Therefore, while planned urban development in the watershed may be expected to increase flood flows a significant but controllable and therefore acceptable amount, as discussed in Chapter IV of this volume, such development should not have a significant impact on extremely low flows.

Background water quality levels typical of those which would be expected during baseflow conditions in the Menomonee River watershed during August were established for the stream system based on actual monitoring data and on information developed during model calibration. The water quality submodel was then used to conduct a quasi-steady state low flow simulation with the intent of representing the corresponding instream water quality conditions at six points along that portion of the main stem of the Menomonee River between the two Menomonee Falls sewage treatment plants on the upstream end and Hawley Road in the City of Milwaukee on the downstream end. The low flow water quality analysis was restricted to this reach of the Menomonee River since, as explained above, the 7 day-10 year low flow in the absence of municipal sewage treatment plants are zero on all other stream reaches in the watershed. Two steady state runs were made initially—one run with the existing four municipal sewage treatment plants and one run assuming that the municipal treatment plants were permanently abandoned.

The water quality submodel model calibration process which is described in Chapter VIII, Volume 1 of this report, indicated that under present conditions, the bottom deposits in the Menomonee River provide a source of phosphorus and exert an oxygen demand. This may be attributed to the long-term deposition of organic material and sediment and adsorbed nutrients onto the channel bottom with the material originating as sewage treatment plant effluent, flow relief device discharge, and wash-off from the land surface. The abandonment of the four municipal sewage treatment plants would substantially reduce one source of organic material and nutrients and may be expected to effect a reduction in the supply of those substances to the channel bottom. Therefore, the model run corresponding to abandonment of the sewage treatment plants assumed that the net phosphorus release rate and oxygen demand rate associated with the bottom deposits would be reduced by one-half along the main stem of the Menomonee River.

It is important to note that, under the late summer low flow conditions assumed for the analysis, both flow and potential pollutants enter the stream system primarily either as groundwater discharge or as effluent from municipal sewage treatment plants since there would be no direct runoff and associated transport of potential pollutants from the land surface and since industrial contributions are small and widely dispersed. Possible secondary sources of both flow and pollutants are septic system effluent that accumulates in drainage swales and roadside ditches and may flow into the stream system and intermittent flow from flushing and washing activities at barnyards and feedlots.

Results: The results of the low flow simulation are set forth in Table 38 which shows the estimated 7 day-10 year low streamflow and the corresponding expected water quality levels for the six locations along the main stem of the Menomonee River under existing land use conditions with and without existing municipal sewage treatment plants. Water quality parameters selected for inclusion in the table include: temperature, dissolved oxygen, fecal coliform bacteria, phosphate expressed as phosphorus, and ammonia expressed as nitrogen. Critical limits for the first three parameters are explicitly set forth in the adopted standards, whereas critical values of the last two parameters are implicit in the standards in that they are taken from Water Quality Criteria [13] which is referenced in the adopted water quality standards.

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[12] *This simulated 7 day-10 year low flow of 4.7 cfs for existing conditions using 10 years of meteorologic data (1965-1974) compares reasonably well with the value of 3.5 cfs based on measured streamflow for the 12-year period of October 1961 through September 1973.*

[13] *Water Quality Criteria, Report of the National Technical Advisory Committee to the Secretary of the Interior, April 1968, Federal Water Pollution Control Administration, 1972.*

Table 38

WATER QUALITY EFFECTS DURING LOW FLOW CONDITIONS OF REMOVING EXISTING MUNICIPAL SEWAGE TREATMENT PLANTS AND OF IMPLEMENTING THE LAND USE PLAN AND LAND MANAGEMENT MEASURES IN THE MENOMONEE RIVER WATERSHED

Location			Existing Land Use Conditions with Four Municipal Sewage Treatment Plants						Existing Land Use Conditions and Abandonment of Four Municipal Sewage Treatment Plants						Planned (Year 2000) Land Use Conditions, Abandonment of Municipal Sewage Treatment Plants and Implementation of Land Management Measures					
Stream	River Mile	Description	7 Day-10 Year Low Flow (cfs)	Temperature (°F)	Dissolved Oxygen (mg/l)	Fecal Coliform (Colonies per 100 ml)	PO_4 as P (mg/l)	NH_3 as N (mg/l)	7 Day-10 Year Low Flow (cfs)	Temperature (°F)	Dissolved Oxygen (mg/l)	Fecal Coliform (Colonies per 100 ml)	PO_4 as P (mg/l)	NH_3 as N (mg/l)	7 Day-10 Year Low Flow (cfs)	Temperature (°F)	Dissolved Oxygen (mg/l)	Fecal Coliform (Colonies per 100 ml)	PO_4 as P (mg/l)	NH_3 as N (mg/l)
Menomonee River	5.14	Hawley Road	4.7	82.8	3.5	28	6.24	0.20	0.5	83.3	5.2	65	1.21	0.08	0.5	80.1	7.6	32	0.01	0.00
	6.33	Upstream of the Confluence with Honey Creek	4.6	76.5	3.6	41	6.20	0.30	0.4	78.8	5.6	100	1.25	0.11	0.4	79.5	7.8	30	0.01	0.00
	8.33	Upstream of the Confluence with Underwood Creek	4.6	78.8	4.6	52	6.02	0.40	0.4	79.0	5.6	163	1.03	0.12	0.4	79.0	7.9	49	0.01	0.00
	12.52	Upstream of the Confluence with Little Menomonee River	4.5	79.5	3.8	90	5.70	1.11	0.3	78.4	5.6	534	0.23	0.11	0.3	78.6	7.8	139	0.01	0.00
	16.65	Waukesha-Milwaukee County Line	4.2	73.9	3.7	102	6.07	1.73	0.3	73.8	4.4	739	0.21	0.53	0.3	73.7	8.3	193	0.01	0.01
	19.07	Upstream of Lilly Creek	3.1	75.2	5.3	86	6.61	1.36	0.1	72.5	6.3	691	0.57	0.12	0.1	74.7	8.3	200	0.01	0.01

NOTE: Underlining indicates failure to meet the following water quality standards: temperature in excess of 89°F, dissolved oxygen below 5.0 mg/l, fecal coliform colonies in excess of 400 MFFCC (Membrane Filter Fecal Coliform Count) per 100 ml, total phosphate (PO_4) as P in excess of 0.10 mg/l which is approximately equivalent to total phosphorus (P) of 0.10 mg/l, ammonia (NH_3) as N in excess of 2.5 mg/l.

Source: SEWRPC.

Temperature: With the presence of the sewage treatment plants and under the assumed 7 day-10 year low flow conditions, temperature standards could be expected to be met along the main stem of the Menomonee River between the confluence with Lilly Creek in Menomonee Falls and Hawley Road in the City of Milwaukee. Average temperatures may be expected to be generally in the 75° to 85° F range which is less than the maximum allowable temperature of 89° F that is specified for maintenance of a warm water fishery. With the abandonment of the sewage treatment plants and under the assumed 7 day-10 year low flow conditions, instream temperatures would be essentially unchanged and temperature standards would be met along the main stem of the Menomonee River.

Since the temperature of sewage treatment plant effluents was assumed to be in the 66° to 75° F range, which is less than the resulting instream temperature, and since the removal of the treatment plant discharge markedly reduces low flow along the main stem of the Menomonee River, an increase in stream temperatures might be expected with removal of the sewage treatment plants. The absence of such an increase indicates that instream temperatures during summer low flow conditions are largely determined by solar radiation and atmospheric temperature. That is, instream temperatures are relatively insensitive to the temperature of inflows—except immediately downstream of the inflow points—even when those discharges to the stream are large and of a different temperature than the stream.

Dissolved Oxygen: Dissolved oxygen standards would not generally be satisfied along the main stem of the Menomonee River between its confluence with Lilly Creek and Hawley Road under the specified late summer flow conditions with the presence of sewage treatment plants. Summer low flow dissolved oxygen concentrations may be expected to range from approximately 3.5 to 5.5 mg/1 with most values being less than the minimum dissolved oxygen concentration of 5.0 mg/1 recommended for maintenance of a warm water fishery. The dissolved oxygen standards would generally be satisfied along the Menomonee River under the specified summer flow conditions with the abandonment of the remaining four municipal sewage treatment plants in that summer low flow dissolved oxygen concentrations may be expected to exceed 5.0 mg/1 at most locations. Therefore, removal of the sewage treatment plants may be expected to affect an improvement in dissolved oxygen levels along the mainstem of the Menomonee River.

Fecal Coliform Bacteria: Fecal coliform concentrations under the simulated summer low flow conditions with municipal sewage treatment plants in operation meet the recreational use standard of 400 colonies per 100 milliliters at all locations along the main stem of the Menomonee River between its confluence with Lilly Road and Hawley Road. Fecal coliform concentrations under summer low flow conditions with the abandonment of the sewage treatment plants could be expected to increase at all points along the main stem of the Menomonee River and would probably exceed the recreational use standard of 400 colonies per 100 milliliters along that portion of the Menomonee River between the confluence with Lilly Creek and the confluence with the Little Menomonee River. Substandard fecal coliform concentrations expected in this reach are attributable to fecal coliform bacteria being carried into the stream from malfunctioning septic tanks in the western portion of the basin and from the many livestock operations in the headwater areas of the watershed in combination with a significant reduction in dilution as a result of a marked decrease in instream low flows.

Phosphate: Concentrations of phosphate-phosphorus may be expected to be about 6.0 mg/1 along the main stem of the Menomonee River between the Lilly Creek confluence and Hawley Road under low flow conditions with the sewage treatment plants in operation. The phosphate-phosphorus levels, which are an approximate measure of total phosphorus concentrations, are in excess of 0.10 mg/1 which is the recognized level of total phosphorus below which nuisance growths of algae and other aquatic plants are not expected to occur in flowing streams.

Phosphate-phosphorus concentrations may be expected to be reduced to about 1.0 mg/1 or less along the main stem of the Menomonee River under the specified low flow conditions and with abandonment of the sewage treatment plants. This is a substantial reduction relative to the phosphorus concentrations of about 6.0 mg/1 expected along the same reach of the Menomonee River with the four municipal sewage treatment plants in place. However, the reduced phosphorus levels could still be expected to be greater than the concentration of 0.1 mg/1 which is recognized as the level of total phosphorus above which nuisance growths of algae and other aquatic plants are expected to occur in the flowing streams. The substandard phosphorus levels that are expected to remain after abandonment of the sewage treatment plants are primarily attributed to the release of phosphorus from channel bottom deposits and the phosphorus content of groundwater discharge to the surface water system, the latter of which may in turn be traced to such sources as effluent from onsite waste disposal systems, fertilizer use in urban and rural areas, and drainage from livestock feedlots.

Ammonia: Under the summer low flow conditions and with the sewage treatment plants in operation, ammonia-nitrogen levels along the main stem of the Menomonee River between the Lilly Creek confluence and Hawley Road may be expected to be in the 0.2 to 2.0 mg/1 range with the highest values occurring in the upper portions of the reach. These ammonia nitrogen concentrations are significantly less than the approximately 2.5 mg/1 level at which fish toxicity problems may be expected under summer flow conditions. Under the summer low flow conditions and with the abandonment of the sewage treatment plants, ammonia nitrogen values along the Menomonee River may be expected to be substantially reduced so as to be less than about 0.5 mg/1 and, therefore, to remain well below the level at which fish toxicity problems may be expected.

Concluding Statement—Effect on Low Flow Water Quality of Abandoning Sewage Treatment Plants: The above water quality analyses indicate that under 7 day-10-year low flow conditions in late summer, in combination with the existing four municipal sewage treatment plants, the main stem of the Menomonee River between the confluence with Lilly Creek in the Village of Menomonee Falls and Hawley Road in the City of Milwaukee may be expected to exhibit water quality levels that meet the temperature, fecal coliform, and ammonia nitrogen standards but will not meet the standards for dissolved oxygen and phosphorus. Removal of the municipal sewage treatment plants, although not expected to affect water temperature significantly, may be expected to significantly increase dissolved oxygen levels, significantly reduce ammonia nitrogen levels, and significantly reduce phosphorus levels. The resulting levels of the latter nutrient, however, may still be in excess of the threshold nuisance growth concentration of 0.1 mg/l. Removal of the municipal sewage treatment plants may be expected to be accompanied by an increas in fecal coliform levels and may produce excessive fecal coliform concentrations along the short portion of the main stem of the Menomonee River in the Village of Menomonee Falls.

In summary, removal of the four municipal sewage treatment plants under existing land use conditions and without any other water pollution abatement measures, may be expected to have the following effects on water quality conditions under 7 day-10 year low flows on the main stem of the Menomonee River: no change in the already acceptable instream temperature, a further reduction in the already acceptable ammonia-nitrogen levels, a significant improvement in dissolved oxygen concentrations so as to meet standards, and significant reduction in phosphorus levels but not sufficient to meet the standards. Removal of the plants may be expected to be accompanied by an increase in the fecal coliform count so as perhaps to exceed the standards in the upstream portion of the river.

It is important to stress that the above analysis applies only to low flow conditions. As pollutant loads to the Menomonee River decrease—as a result of abandonment of sewage treatment plants—so does streamflow and, therefore, the concentration of some constituents, such as fecal coliform, may actually increase. Importantly, however, and as discussed in the subsequent section of this report, removal of municipal sewage treatment plants from the watershed stream system may be expected to substantially reduce the total load of potential pollutants transported by the Menomonee River and carried into the Milwaukee estuary and into Lake Michigan.

Low Flow Analysis for Year 2000 Plan Land Use with Management Measures

The above low flow analysis for existing land use conditions indicated that, while abandonment of the four municipal sewage treatment plants may be expected to improve instream dissolved oxygen, phosphorus, and ammonia nitrogen conditions, the resulting water quality would not meet the phosphorus and fecal coliform standards. Inasmuch as the target year of the watershed plan is the year 2000, another low flow analysis was conducted to incorporate those watershed changes that are likely to occur by the year 2000 and are likely to affect low flow water quality. These changes include additional planned urban development and, as recommended in the adopted regional sanitary sewerage system plan and incorporated into the Menomonee River watershed plan, the provision of sanitary sewer service to all new urban development as well as to existing unsewered urban development. It is also reasonable to expect, by the design year 2000, the implementation of various land management measures to the urban and rural portion of the watershed intended to significantly reduce the transport of pollutants from the land surface to the stream system via surface washoff during and immediately after rainfall and snowmelt events and by groundwater discharge to the streams. Table 39 sets forth types of surface water pollution known to exist in the Menomonee River watershed, the likely source or origin of that pollution, and rural and urban land management measures available for reducing the transport of pollutants from the land surface to the stream system. Many such measures and combinations thereof could be applied to the Menomonee River watershed to substantially reduce the residual low flow pollution problem as well as the land surface washoff pollution problem that may be expected to remain upon abandonment of the municipal sewage treatment plants. In addition to provision of sanitary sewage service to existing unsewered urban development and to planned urban development, land management measures should be implemented on the Menomonee River watershed including feedlot and agricultural land runoff controls in the headwater areas since the low flow condition fecal coliform and phosphorus pollution problems are likely to be largely attributable to a combination of onsite waste disposal systems, feedlots, and runoff from agricultural lands.

Procedure: Two basic changes were made in the above run that represented existing conditions without sewage treatment plants so as to reflect year 2000 plan land use conditions without sewage treatment plants and with land management measures. First, the net effect of phosphorus release and oxygen demand associated with stream bottom deposits was assumed to be zero to reflect the expected substantial reduction in the load of organic material and nutrients from land surface washoff and groundwater discharge to the stream system. Second, background concentrations of phosphorus, carbonaceous biochemical oxygen demand, ammonia-nitrogen, nitrite-nitrogen, and nitrate-nitrogen were reduced by one-half to reflect the expected reduction in the concentration of these potential pollutants in groundwater as a result of implementation of land management measures. Background fecal coliform levels were reduced by 75 percent in the upper two-thirds of the watershed where pollution from onsite waste disposal systems and from feed lots, which are concentrated in these areas, would be abated by the year 2000 and a 50 percent reduction in fecal coliform counts was used in the remainder of the watershed.

Results: The results of the low flow simulation are set forth in Table 38 which shows the estimated 7 day-10 year low flow and the corresponding expected water quality levels for six locations along the main stem of the Menomonee River under year 2000 planned land use conditions with abandonment of sewage treatment plants and with implementation of land management measures. Relative to existing conditions with abandonment of the four municipal sewage treatment plants—which would yield instream water quality conditions satisfying the temperature, dissolved oxygen, and ammonia nitrogen standards but not the fecal coliform and phosphorus standards—year 2000 plan conditions with land management measures and under the assumed late summer low flow conditions would:

- Produce no significant change in water temperature. Temperatures would be in the 75-80°F range which is less than the maximum allowable temperature of 89°F that is specified for maintenance of a warm water fishery.
- Increase dissolved oxygen concentrations to a range of approximately 7.5 to 8.5 mg/1 exceeding the minimum of 5.0 mg/1 recommended for maintenance of a warmwater fishery.
- Decrease fecal coliform bacteria levels to less than 200 colonies per 100 ml which is less than the recreational use standard maximum of 400 colonies per 100 ml/.
- Decrease phosphate-phosphorus concentrations to about 0.01 mg/1 which is an approximate measure of total phosphorus levels and which is less than 0.10 mg/1, the recognized level of total phosphorus below which nuisance growths of algae and other aquatic plants are not expected to occur in flowing streams.
- Decrease ammonia-nitrogen levels to 0.01 mg/1 or less, which is much less than the approximately 2.5 mg/1 concentration at which fish toxicity problems may be expected.

Concluding Statement—Effect on Low Flow Water Quality of Year 2000 Land Use Plan with Land Management Measures: Implementation of the year 2000 land use plan in combination with abandonment of the remaining four municipal sewage treatment plants and application of land management measures may be expected to yield water quality levels along the main stem of the Menomonee River in Waukesha County and in Milwaukee County above Hawley Road under later summer 7 day-10 year low flow conditions that meet and exceed the minimum water quality standards. More specifically, surface water temperature, dissolved oxygen content, fecal coliform levels, phosphorus concentration, and ammonia-nitrogen levels will be such as to permit recreational use and maintenance of fish and aquatic life as set forth in the recommended watershed development objectives. For the remainder of the stream system—the Menomonee River in Germantown and tributaries to the Menomonee River such as the Little Menomonee River and Underwood Creek—the standards supporting the water quality objectives cannot be achieved under year 2000 plan conditions for hydrologic reasons in that the expected 7 day-10 year low flow may be expected to be zero.

Table 39

DIFFUSE SOURCE POLLUTION SOURCES, SURFACE WATER POLLUTION PROBLEMS, AND AVAILABLE LAND MANAGEMENT AND RELATED POLLUTION CONTROL MEASURES

Rural Area

Source or Origin of Diffuse Source Pollution	Associated Types of Surface Water Pollution							Available Land Management and Related Pollution Control Measures[a]
	Toxic	Organic-Oxygen Demanding	Nutrient	Pathogenic	Thermal	Sediment	Aesthetic	
Manure and chemical fertilizers and pesticides applied to agricultural land	--	X	X	X	--	--	X	Avoid steep slopes; do not apply on frozen ground; match crop need and soil properties; work into soil
Soil erosion from agricultural land	--	X	X	X	--	X	X	Practice contour plowing, strip cropping and minimum tillage; construct bench terraces; maintain vegetative strips along streams and drainageways; develop grassed waterways
Feedlot runoff	--	X	X	X	--	X	X	Site far from stream; avoid steep slopes; use berms and channels to divert storm water around feedlot; install drain tile to collect liquid wastewater from feedlot; construct manure storage facility and provide for land disposal of solids and liquids; develop retention pond with aeration equipment for biological treatment; confine animals in barn equipped with waste-holding system
Sewage treatment plant sludge spread on the land	X	X	X	X	--	X	X	Provide adequate digestion prior to land application; avoid spreading on steep slopes and floodplains and other low-lying areas; construct terraces or earth berms if slope problems exist; apply only to deep, permeable soils; do not spread on land on which crops are grown for direct consumption by humans; control animal grazing on pasture where sludge has been recently spread; avoid close proximity to urban development, water supply wells, and streams and creeks; consider sludge composition relative to nutrient requirements of intended crop or other vegetal cover; match timing of application to moisture conditions; work deposited sludge into soil

Table 39 (continued)

Urban Area

Source or Origin of Diffuse Source Pollution	Associated Types of Surface Water Pollution							Available Land Management and Related Pollution Control Measures[a]
	Toxic	Organic-Oxygen Demanding	Nutrient	Pathogenic	Thermal	Sediment	Aesthetic	
Washoff from the urban land surface via streets, highways, and the storm sewer system	X	X	X	X	--	X	X	Improved street and highway cleaning procedures such as: use of vacuum sweepers, slower sweepers and increased frequency of sweeping, and parking restrictions to permit access to curb areas; cleaning of catch basins; repair of pavements; maintenance of vegetative zones parallel to streams and drainage ways; use of turf swales; storm water treatment using: screening, dissolved air flotation, detention-retention storage for settling and possible chemical treatment, disinfection, swirl concentrator
Urban litter	--	X	--	X	--	X	X	Public awareness through education; provision of trash receptacles in public areas; improved trash collection schedules; anti-litter ordinances; domestic animal license and control laws
Pesticides and chemical and organic fertilizers applied to public and private lawns and gardens	X	X	X	--	--	--	X	Match application rate to need; control ordinances
Waste pumped out of septic tanks and holding tanks	X	X	X	X	--	--	X	Disposal (with permit) at sewage treatment facility or into sanitary sewerage system

Continuous Flow Analysis for Existing Land Use Conditions With and Without Sewage Treatment Plants and for Planned Use Without and With Land Management Measures

A strict interpretation of the hydrologic conditions—that is, the 7 day-10 year low flow—associated with the State of Wisconsin water quality objectives and standards would require that the standards be satisfied throughout the Menomonee River watershed stream system for all stream flows at or above the 7 day-10 year flow. More specifically, such a strict interpretation would require satisfying the instream quality standards during a wide spectrum of hydrologic-hydraulic-water quality conditions. These conditions may range from late summer-early fall low flow conditions when the stream flow is made up essentially of base flow and sewage treatment plant discharges to spring rainfall-snowmelt conditions when base flow and sewage treatment plant discharges may be expected to account for only a small portion of both streamflow and of potential pollutants, with most of the discharge of water and potential pollutants to the streams being attributable to direct runoff from the rural and urban land surfaces.

It is possible for a combination of antecedent conditions and runoff conditions to occur so that instream water quality levels briefly fall outside of the concentrations specified in the established water quality standards even though relatively high stream flows exist. For example, the water use objective governing recreational use and fish and aquatic life applies to most of the Menomonee River stream system, and the corresponding water quality standard specifies that dissolved oxygen concentration shall be maintained at or above a level of 5.0

Table 39 (continued)

Rural and Urban Areas

Source or Origin of Diffuse Source Pollution	Associated Types of Surface Water Pollution: Toxic	Organic-Oxygen Demanding	Nutrient	Pathogenic	Thermal	Sediment	Aesthetic	Available Land Management and Related Pollution Control Measures[a]
Construction and demolition activity	--	--	--	--	--	X	X	Construct temporary sediment basins; install straw bale dike; use fiber mats, mulching and seeding; install slope drains to stabilize steep banks; construct temporary diversion swale or berm on up-slope edge of project
Highway and street deicing	X	--	--	--	--	X	X	Control material used and location, quantity, manner, and frequency of application
Washout and dry fallout from the atmosphere	X	--	X	--	--	X	X	Minimize wind erosion, use non-leaded fuels, control industrial emissions
Stored materials	X	X	X	X	X	X	X	Cover and/or enclose potentially hazardous materials, construct dikes-channels to divert storm water around storage areas, construct containment dikes and establish emergency procedures as a precaution against accidental spills, anchor materials stored in low areas subject to storm water or floodwater inundation

[a] *In addition to mitigating surface water pollution, some of these land management measures may also be expected to protect groundwater quality. Measures intended for agricultural lands should be integrated into conservation plans for individual farmsteads.*

Sources:

1. *American Public Works Association and the Federal Water Pollution Control Administration, Water Pollution Aspects of Urban Runoff, Section 6, "Measures for Reducing the Pollution Potential in the Urban Setting," June 1969, pp. 127-143.*

2. *R. C. Loehr, "Agricultural Runoff-Characteristics and Control," Journal of the Sanitary Engineering Division-ASCE, December 1972, pp. 909-925.*

3. *Miami Conservancy District and Stanley Consultants, Non-Point and Intermittent Point Source Controls, Section 8, "Structural Control Alternatives," January 1976, pp. 77-94.*

4. *J. Tourbier and R. Westmacott, Water Resources Protection Measures in Land Development—A Handbook, Water Resources Center, University of Delaware, April 1974, 237 pp.*

5. *U. S. Department of Agriculture, Soil Conservation Service—Maryland, Standards and Specifications for Soil Erosion and Sediment Control in Developing Areas, College Park, Maryland, July 1975.*

6. *Wisconsin Department of Natural Resources, "Guidelines for Application of Wastewater Sludge to Agricultural Land in Wisconsin," Technical Bulletin No. 88, 1975, 36 pp.*

7. *SEWRPC.*

mg/1. If an intense rainfall occurs on a part of the watershed after a long, dry period during which organic oxygen-demanding materials have accumulated on the land surface, the sudden washoff of those organic materials to the stream system may be expected to briefly depress dissolved oxygen levels below the specified standard.

To be realistic, water quality standards in support of water use objectives must recognize the vagaries of the hydrologic-hydraulic-water quality processes and accept the possibility of "failure" under both extremely low and extremely high flow conditions. This can be accomplished by applying water quality standards within the context of an analytic technique that predicts the fraction of time that desirable water quality levels may be expected to occur. Therefore, the water quality analysis conducted under the Menomonee River watershed planning program was carried beyond the "low flow approach"—the application of which was described in the preceding section of this chapter—and the concept was applied that specified water quality levels should be tested for all streamflow conditions. The continuous process water quality analyses reported below resulted in water quality-duration relationships used to quantitatively display and to evaluate the impact of the full spectrum of hydrologic-hydraulic-water quality phenomena on instream water quality levels.

Procedure: Four continuous flow simulation runs were made with the Water Quality Submodel in order to determine the overall impact of the full spectrum of hydrologic-hydraulic-water quality processes on instream water quality. More specifically, the water quality submodel was operated for the entire Menomonee River watershed under existing conditions with and without the four remaining municipal sewage treatment plants and under 2000 plan conditions without and with land management measures. A 10-year period extending from January 1965 through December 1974 was continuously simulated at one-hour intervals by inputing continuous meteorologic data for the same period to obtain, at each of the 12 selected output stations shown on Map 48, a long-term data series on which statistical analyses were performed. The 10-year simulation period was selected as being long enough to provide meaningful statistical results while being short enough so as to result in reasonable computer system operation costs.

As indicated above, the water quality submodel calibration process suggests that, under present conditions, the bottom deposits in the Menomonee River provide a source of phosphorus and exert an oxygen demand. The abandonment of the four municipal sewage treatment plants would substantially reduce a source of organic material and nutrients and may be expected to effect a reduction in the supply of such substances to the channel bottom. Therefore, in the model runs corresponding to existing conditions without municipal sewage treatment plants and year 2000 planned land use conditions without land management, the net phosphorus release rate and the oxygen demand rate associated with bottom deposits along the main stem of the Menomonee River below the four municipal sewage treatment plants were reduced by one-half.

After completing the third model run—year 2000 conditions without sewage treatment plants and without land management measures—three basic changes were made in model input so as to facilitate the fourth model run intended to simulate the year 2000 plan land use conditions without sewage treatment plants but with land management measures. First, the net effect of phosphorus release and oxygen demand associated with the stream bottom deposits were assumed to be zero at all points in the watershed to reflect the expected substantial reduction in the load or organic material and nutrients from land surface washoff and groundwater discharged through the stream system. Second, groundwater concentrations of phosphorus, carbonaceous biochemical oxygen demand, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and total dissolved solids were reduced by one-half to reflect the expected reduction and the concentration of these potential pollutants in groundwater as a result of implementation of the land management measures. Background fecal coliform levels were reduced by 75 percent in the upper two-thirds of the watershed where pollution from onsite waste disposal systems and from feedlots which are concentrated in those areas would be abated by the year 2000 with application of land management measures; and a 50 percent reduction in fecal coliform counts was used in the remainder of the watershed. Third, land surface accumulation rates of phosphorus, carbonaceous biochemical oxygen demand, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, and total dissolved solids were reduced by one-half to reflect the expected reduction in the loading of these potential pollutants on the land surface as a result of implementation of land management measures. Fecal coliform land surface loading rates were reduced by 75 percent in the upper two-thirds of the watershed where pollution of onsite waste disposal systems and from feedlots would be abated by the year 2000, and a 50 percent reduction in fecal coliform loading rates was used in the remainder of the watershed.

For each of the 12 output locations in the watershed, each of the four 10-year simulation runs yielded a series of computed hourly stream flows and series of computed hourly values for the following nine water quality parameters: dissolved oxygen, ultimate carbonaceous biochemical oxygen demand, total dissolved solids, fecal coliform count, nitrate nitrogen, nitrite nitrogen, ammonia nitrogen, phosphate-phosphorus, and water temperature. A voluminous amount of water quality values was thus computed in the simulation process. For example, for each of the above four runs, 10 years of hourly computations for all of the above nine water quality parameters at all of the 12 output locations yields a total of about 9,460,800 simulated quality values.

Because it was not practicable to manually display, examine, and analyze this voluminous data series, statistical analyses were performed to produce water quality-duration curves for each parameter at each location and for each of the four conditions, that is, with and without the four sewage treatment plants under existing conditions and without and with land management measures under year 2000 plan conditions. A water quality-duration curve is similar to the flow-duration curve commonly used in hydrology, and is a graph showing on the vertical axis the percent of time during which an indicated concentration of the water quality parameter, shown on the horizontal axis, is reached and exceeded or is not reached or exceeded. The water quality-duration relationship for one parameter under one condition at one of the 12 output locations in the watershed was constructed using the 87,600 water quality values resulting from continuous hourly computations for a period of 10 years.

Water quality-duration relationships represent the overall impact of all the hydrologic-hydraulic-water quality processes that were simulated over the 10-year period weighing their impact in accordance with the frequency and magnitude with which they occur. The water quality-duration curves were based on the total universe of water quality values that were generated, during simulation, in the stream system and permit an estimation of the percent of time that a desired water quality level will or will not be maintained. This approach is fundamentally different than that which specifies one "critical" hydrologic-hydraulic condition—such as the 7 day-10-year low flow condition—under which pollution abatement measures are to be examined. In contrast with water quality-duration relationship approach, the "critical" condition approach does not provide an indication of how often or what percent of the time desired water quality levels will be maintained since, for example, it may not be assumed that a 10-year recurrence interval streamflow corresponds to a 10-year water quality condition. The construction of water quality-duration relationships for selected parameters at each location of interest in the watershed for different conditions or management alternatives concisely summarizes the expected impact of the condition or management alternative on the full range of water quality phenomena.

Results—Concentrations: Figures 24 through 43 show water quality-duration curves under existing conditions with and without municipal sewage treatment plants and for year 2000 plan conditions without and with land management measures for four water quality parameters—temperature, dissolved oxygen, fecal coliform bacteria, and phosphate phosphorus—for the following five locations in the watershed stream system: the Menomonee River at Hawley Road, the Menomonee River immediately above the confluence with the Little Menomonee River, the Little Menomonee River at the Menomonee River, Underwood Creek at the Menomonee River, and Honey Creek at the Menomonee River. Table 40 shows the average annual transport of carbonaceous biochemical oxygen demand, phosphate-phosphorus, total dissolved solids, ammonia nitrogen, nitrate-nitrogen, and nitrite-nitrogen at each of the above five locations for each of the above four conditions. Model results presented in Figures 24 through 43 and in Table 40 for the five specified locations are representative results selected from the total set of results for all parameters modeled and for all 10 locations at which Water Quality Submodel output were obtained.

Temperature: Figure 24 shows temperature conditions on the Menomonee River immediately upstream of its confluence with the Little Menomonee River (River Mile 12.52) and indicates the percent of time that a specified water temperature may be expected to be reached or exceeded. Under existing conditions, water temperatures could be expected to be altered an insignificant amount by removal of the upstream sewage treatment plants—one serving Germantown, two serving Menomonee Falls, and one serving Butler—in that the temperature-duration curve at this location for existing conditions without the sewage treatment plants is essentially coincident with that for existing conditions with the sewage treatment plants. Furthermore, implementation of the year 2000 land use plan, in addition to removing the treatment plants, could be expected to have no significant effect on water temperatures nor will implementation of land use management measures in that the resulting temperature-duration relationships are almost coincident with those for existing conditions with and without sewage treatment plants. Under year 2000 planned land use with abandonment of municipal sewage treatment plants and implementation of land management measures, the recommended maximum temperature of 89°F for fish and aquatic life may be expected to be reached or exceeded only about 6 percent of the time at this location.

Figure 25, which shows temperature conditions on the Menomonee River in the City of Milwaukee at Hawley Road (River Mile 5.14), reveals similar results: the temperature-duration curves at this location under existing land use conditions, with and without the four upstream sewage treatment plants, and under year 2000 plan conditions, with sewage treatment plants and without land management measures development, are essentially coincident. Under plan conditions, the recommended maximum temperature of 89°F for fish and aquatic life would be exceeded only about 6 percent of the time at this location.

Figure 26 shows temperature conditions on the Little Menomonee River immediately above its confluence with the Menomonee River. There are no municipal sewage treatment plants discharging to the Little Menomonee River upstream of this location. The temperature-duration curve indicates that implementation of the year 2000 land use plan, with or without land management measures, may be expected to have no significant effect on water temperatures in that the resulting temperature-duration relationship is coincident with that for existing conditions. Under plan conditions, the recommended maximum temperature of 89°F for fish and aquatic life may be expected to be reached or exceeded less than 1 percent of the time at this location.

Figure 27 shows temperature conditions on Underwood Creek immediately above its confluence with the Menomonee River. There are no municipal sewage treatment plants discharging to Underwood Creek upstream of this

Table 40

POLLUTANT TRANSPORT IN THE MENOMONEE RIVER WATERSHED STREAM SYSTEM UNDER EXISTING AND PLANNED CONDITIONS

Location: Stream	Location: River Mile	Location: Description	Tributary Area (mi^2)	Tributary Area (acres)	Existing Percent Urban Land Use (1970)	Constituent	Average Annual Pollutant Transport[a]: Existing Land Use With Municipal Sewage Treatment Plants (1,000 lbs.)	(lb/acre)	Existing Land Use Without Municipal Sewage Treatment Plants (1,000 lbs.)	(lb/acre)	Year 2000 Plan Land Use Without Municipal Sewage Treatment Plants (1,000 lbs.)	(lb/acre)	Year 2000 Plan Land Use Without Municipal Sewage Treatment Plants with Land Management (1,000 lbs.)	(lb/acre)
Menomonee River	5.41	Hawley Road	127.52	81,613	50	PO_4-P	99	1.2	42	0.5	53	0.6	10	0.1
						NH_3-N	483	5.9	353	4.3	298	3.7	51	0.6
						$CBOD_{ult}$	782	9.6	616	7.5	773	9.5	276	3.4
						TDS	142,000	1,740	135,000	1,654	163,500	2,003	79,700	976
						NO_2-N	2	0.0[b]	1	0.0[b]	1	0.0[b]	2	0.0[b]
						NO_3-N	304	3.7	240	2.9	216	2.6	32	0.4
	12.52	Upstream of Confluence with Little Menomonee River	60.41	38,662	31	PO_4-P	65	1.7	12	0.3	19	0.5	8	0.2
						NH_3-N	36	0.9	17	0.4	25	0.7	7	0.2
						$CBOD_{ult}$	476	12.3	249	6.5	355	9.2	91	2.4
						TDS	51,000	1,319	41,200	1,066	56,600	1,464	27,700	717
						NO_2-N	15	0.4	4	0.1	5	0.1	2	0.0[b]
						NO_3-N	161	4.2	104	2.7	91	2.4	40	1.0
Little Menomonee River	0.00	At Menomonee River	22.12	14,157	35	PO_4-P	4	0.3	4	0.3	5	0.4	3	0.2
						NH_3-N	6	0.4	6	0.4	9	0.6	3	0.3
						$CBOD_{ult}$	124	8.8	124	8.8	127	9.0	30	2.1
						TDS	18,800	1,328	18,800	1,328	19,500	1,377	9,400	664
						NO_2-N	1	0.1	1	0.1	1	0.1	0.4	0.0[b]
						NO_3-N	41	2.9	41	2.9	34	2.4	17	1.2
Underwood Creek	0.00	At Menomonee River	20.21	12,934	76	PO_4-P	7	0.5	7	0.5	9	0.7	4	0.3
						NH_3-N	37	2.9	37	2.9	9	0.7	4	0.3
						$CBOD_{ult}$	128	9.9	128	9.9	167	12.9	61	4.7
						TDS	24,600	1,902	24,600	1,902	30,600	2,366	14,700	1,137
						NO_2-N	1	0.1	1	0.1	1	0.1	1	0.1
						NO_3-N	41	3.2	41	3.2	41	3.2	20	1.6
Honey Creek	0.00	At Menomonee River	10.82	6,925	90	PO_4-P	8	1.2	8	1.2	8	1.2	4	0.6
						NH_3-N	8	1.2	8	1.2	11	1.6	5	0.7
						$CBOD_{ult}$	103	14.9	103	14.9	130	18.8	57	8.2
						TDS	21,200	3,061	21,200	3,061	26,800	3,870	13,400	1,935
						NO_2-N	2	0.3	2	0.3	2	0.3	1	0.1
						NO_3-N	18	2.6	18	2.6	15	2.2	8	1.2

[a] *Based on 10 years (1965-1974) of continuous simulation.*

[b] *Less than 0.05 lb/acre.*

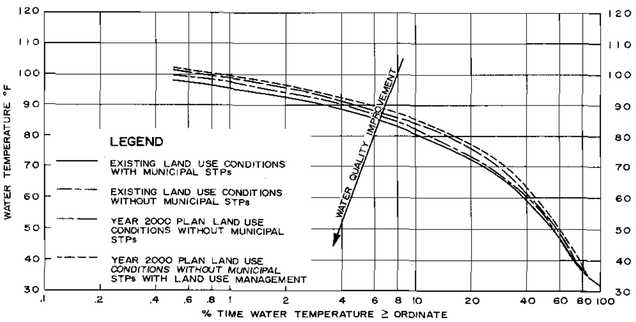
Source: SEWRPC.

location. The temperature-duration relationships indicate that implementation of the year 2000 land use plan, with or without land management measures, will have no significant effect on water temperatures in Underwood Creek in that the resulting temperature-duration relationship is coincident with that for existing conditions. Under plan conditions, the recommended maximum temperature of 89°F for fish and aquatic life may be expected to be reached or exceeded only about 7 percent of the time at this location. This temperature standard is not applicable at this location since a restricted use objective, which has no maximum temperature associated with it, has been assigned to the 3.67-mile-long reach of Underwood Creek downstream of the Juneau Boulevard crossing in the Village of Elm Grove. However, the temperature-duration relationship at the downstream end of Underwood Creek may be considered representative of that which would be expected to occur along Underwood Creek upstream of the Juneau Boulevard crossing where fish and aquatic life objectives, and therefore, a maximum temperature standard, are applicable.

Figure 28 shows temperature conditions on Honey Creek immediately above its confluence with the Menomonee River. There are no municipal sewage treatment plants discharging to Honey Creek. The temperature-duration relationships indicate that implementation of the year 2000 land use plan, with or without land management

Figure 24

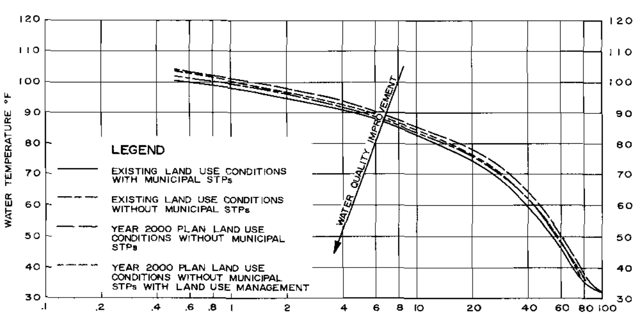
TEMPERATURE-DURATION RELATIONSHIPS FOR THE MENOMONEE RIVER IMMEDIATELY UPSTREAM OF THE LITTLE MENOMONEE RIVER



Source: SEWRPC.

Figure 25

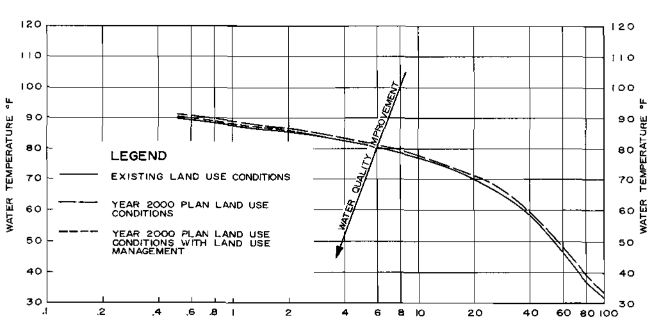
TEMPERATURE-DURATION RELATIONSHIPS FOR THE MENOMONEE RIVER AT HAWLEY ROAD



Source: SEWRPC.

Figure 26

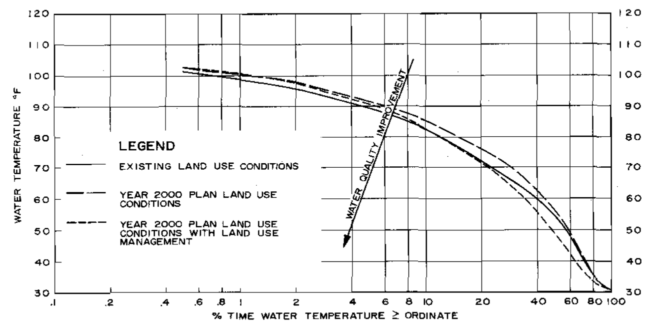
TEMPERATURE-DURATION RELATIONSHIPS FOR THE LITTLE MENOMONEE RIVER AT THE MENOMONEE RIVER



Source: SEWRPC.

Figure 27

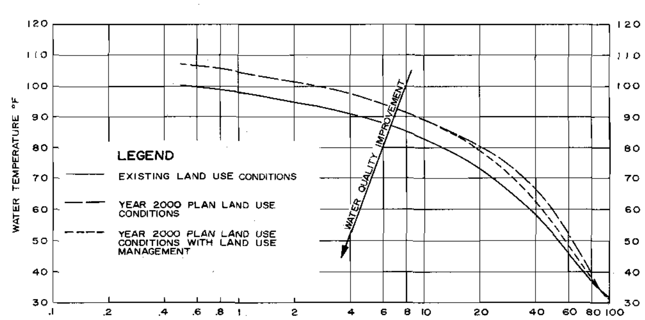
TEMPERATURE-DURATION RELATIONSHIPS FOR UNDERWOOD CREEK AT THE MENOMONEE RIVER



Source: SEWRPC.

Figure 28

TEMPERATURE-DURATION RELATIONSHIPS FOR HONEY CREEK AT THE MENOMONEE RIVER



Source: SEWRPC.

measures, may be expected to have no significant effect on water temperatures in that the resulting year 2000 temperature-duration relationships are not significantly different than for existing conditions. Although a maximum temperature standard is not applicable to Honey Creek since the water use objectives do not call for maintenance of fish and aquatic life in this stream, the temperature-duration curves indicate that a maximum temperature of 89°F specified for maintenance of fish and aquatic life may, under year 2000 conditions, be expected to be exceeded about 10 percent of the time.

Dissolved Oxygen: Figure 29 shows dissolved oxygen conditions on the Menomonee River immediately above its confluence with the Little Menomonee River and indicates the percent of time that dissolved oxygen levels within the stream will be less than or equal to specified concentration. For example, under existing conditions, the dissolved oxygen level may be expected to fall below the recommended minimum concentration of 5.0 mg/l for fish and aquatic life about 7 percent of the time.

Under existing conditions, dissolved oxygen concentrations would be altered an insignificant amount by removal of the four upstream sewage treatment plants in that the dissolved oxygen-duration curve at this location for existing conditions without the sewage treatment plants approximates that for existing conditions with the sewage treatment plants. Under year 2000 land use plan conditions, with removal of the treatment plants but without land management measures, no significant change in dissolved oxygen levels would be expected. Under year 2000 planned land use, with abandonment of the municipal sewage treatment plants and with land management measures, dissolved oxygen levels could be expected to increase markedly and may always be expected to remain above the recommended minimum concentration of 5.0 mg/l for fish and aquatic life.

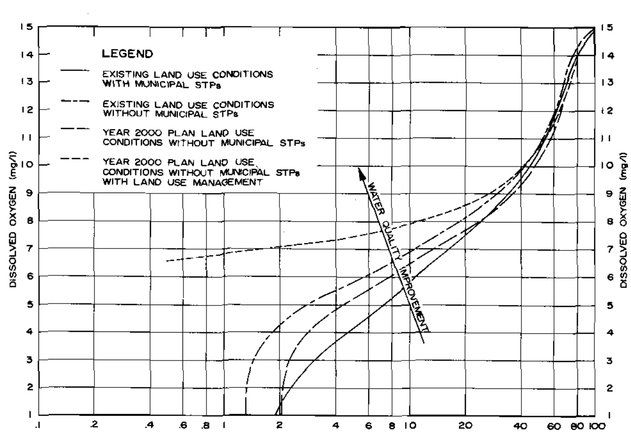
Figure 30 shows dissolved oxygen conditions on the Menomonee River at Hawley Road which are similar to those for the upstream location. The dissolved oxygen-duration curves at this location under existing conditions without the four upstream sewage treatment plants approximate that for existing conditions with the sewage treatment plants. Under year 2000 land use plan conditions, with removal of the treatment plants but without land management measures, no significant change in dissolved oxygen levels would be expected. Under year 2000 planned land use, with abandonment of municipal sewage treatment plants and with implementation of land management measures, dissolved oxygen levels may be expected to improve markedly and remain above the recommended minimum concentration of 5.0 mg/l for fish and aquatic life.

Figure 31 shows dissolved oxygen conditions at the discharge end of the Little Menomonee River subwatershed—a portion of the Menomonee River watershed in which there are no municipal sewage treatment plants. The dissolved oxygen-duration relationships indicate that, under year 2000 land use plan conditions but without land management measures, there would be no significant change in dissolved oxygen levels. Under such conditions, dissolved oxygen levels may be expected to fall below the recommended minimum concentration of 5 mg/l only about 4 percent of the time. Under year 2000 planned land use with land management measures, dissolved oxygen levels may be expected to remain above the recommended minimum concentration of 5.0 mg/l for fish and aquatic life essentially all of the time.

Figure 32 shows dissolved oxygen conditions at the discharge end of the Underwood Creek subwatershed—a portion of the watershed in which there are no municipal sewage treatment plants. The dissolved oxygen-

Figure 29

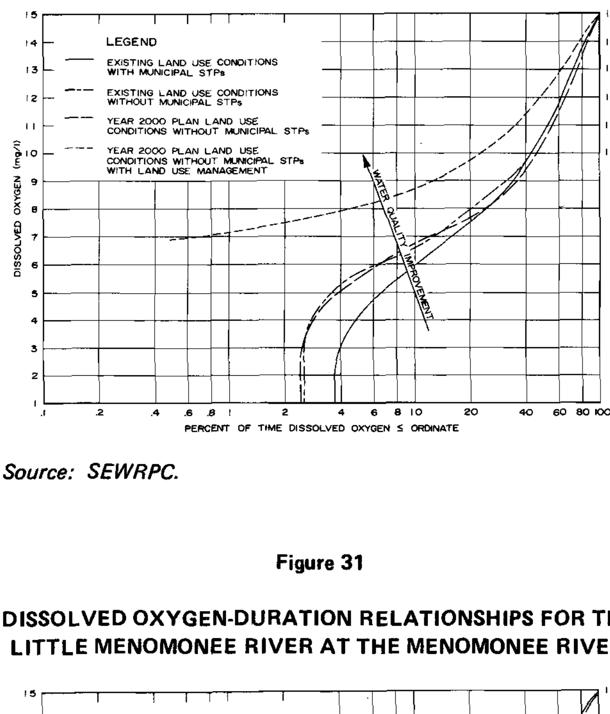
DISSOLVED OXYGEN-DURATION RELATIONSHIPS FOR THE MENOMONEE RIVER IMMEDIATELY UPSTREAM OF THE LITTLE MENOMONEE RIVER



Source: SEWRPC.

Figure 30

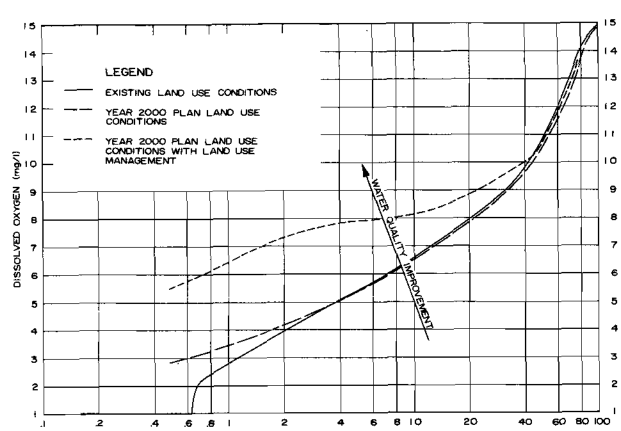
DISSOLVED OXYGEN-DURATION RELATIONSHIPS FOR THE MENOMONEE RIVER AT HAWLEY ROAD



Source: SEWRPC.

Figure 31

DISSOLVED OXYGEN-DURATION RELATIONSHIPS FOR THE LITTLE MENOMONEE RIVER AT THE MENOMONEE RIVER



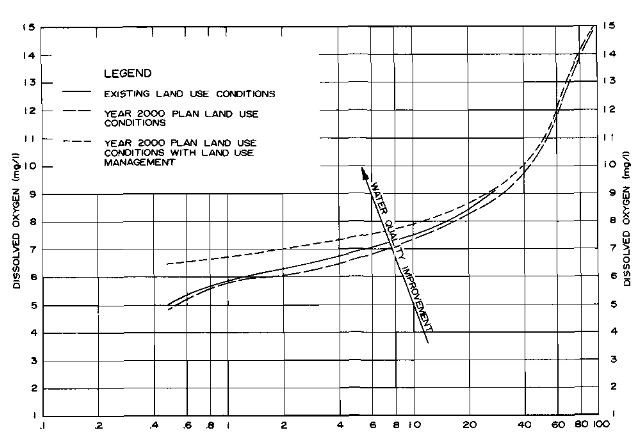
Source: SEWRPC.

duration relationships indicate that, under year 2000 land use plan conditions but without land management measures, there would be no significant change in dissolved oxygen levels. Under such conditions, dissolved oxygen levels at this location may be expected to fall below the recommended minimum concentration of 5.0 mg/l less than 1 percent of the time. This dissolved oxygen standard is not applicable at this location since a restricted use objective, which has a lower minimum dissolved oxygen level of 2.0 mg/l associated with it, has been assigned to Underwood Creek downstream of Juneau Boulevard in the Village of Elm Grove. However, the dissolved oxygen-duration relationship at the downstream end of Underwood Creek may be considered representative of that which would be expected to occur along Underwood Creek upstream of the Juneau Boulevard crossing where fish and aquatic life objectives and, therefore, a minimum 5.0 mg/l dissolved oxygen standard, is applicable. Under year 2000 planned land use with management measures, dissolved oxygen levels may be expected to remain above the recommended minimum concentration of 5.0 mg/l for fish and aquatic life essentially all of the time.

Figure 33 shows dissolved oxygen concentrations at the discharge end of the Honey Creek subwatershed—a portion of the watershed stream system in which there are no municipal sewage treatment plants. The dissolved oxygen-duration relationships indicate that planned urban development, with or without land management measures, will probably have no significant effect on dissolved oxygen levels. Under year 2000 plan conditions, with or without land management measures, dissolved oxygen levels may be expected to be above the recommended minimum concentration of 2.0 mg/l for restricted use all of the time.

Figure 32

DISSOLVED OXYGEN-DURATION RELATIONSHIPS FOR UNDERWOOD CREEK AT THE MENOMONEE RIVER

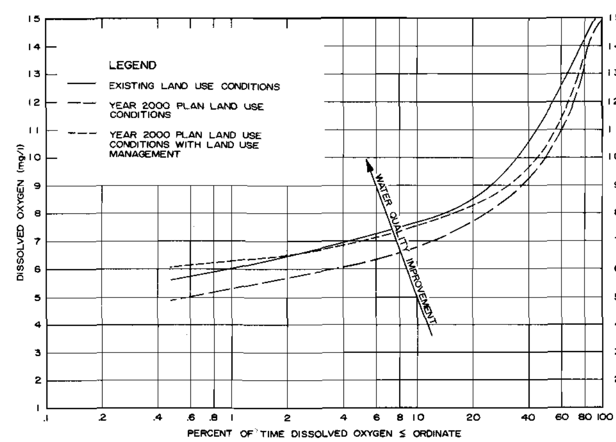


Source: SEWRPC.

Fecal Coliform: Figure 34 shows fecal coliform conditions on the Menomonee River immediately upstream of its confluence with the Little Menomonee River and indicates the percent of time that a specified fecal coliform count may be expected to be reached or exceeded. Under existing conditions, at this location, the maximum fecal coliform concentration of 400 colonies per 100 ml recommended for recreational use of surface waters may be expected to be exceeded almost 30 percent of the time. Fecal coliform concentrations would be altered a small amount with removal of the four upstream sewage treatment plants in that the fecal coliform-duration curve at this location for existing conditions without the sewage treatment plants shows a slight deterioration over

Figure 33

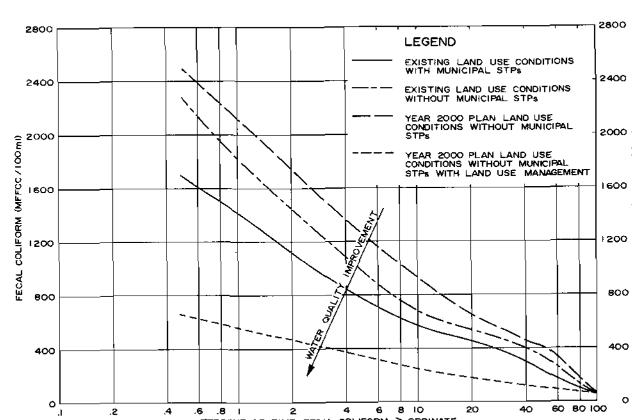
DISSOLVED OXYGEN-DURATION RELATIONSHIPS FOR HONEY CREEK AT THE MENOMONEE RIVER



Source: SEWRPC.

Figure 34

FECAL COLIFORM-DURATION RELATIONSHIPS FOR THE MENOMONEE RIVER IMMEDIATELY UPSTREAM OF THE LITTLE MENOMONEE RIVER



Source: SEWRPC.

that for existing conditions with the sewage treatment plants. Although removal of the sewage treatment plants will eliminate a source of fecal coliform bacteria, that positive effect is offset by diminished streamflows and, therefore, reduced potential for dilution of fecal coliform bacteria from other sources such as onsite waste disposal systems and domestic and farm animals. Implementation of the year 2000 land use plan, in addition to removing the treatment plants, will have no significant effect on fecal coliform levels in that the concentration-duration relationship follows the general form of, but shows a slight deterioration relative to, that for existing conditions with sewage treatment plants. It appears as though the positive effect of reducing the input of coliform bacteria to the stream system by removing the sewage treatment plants is more than offset by the reduction in stream flow and, therefore, the reduction in dilution potential, and by the increased contribution of bacteria to the stream system as the result of the planned incremental urban development. Under year 2000 planned land use conditions, with abandonment of municipal sewage treatment plants and with implementation of land management measures, fecal coliform levels would decrease markedly so that the recommended maximum fecal coliform count of 400 colonies per 100 milliliters for recreational use may be expected to be reached or exceeded only about 3 percent of the time at this location.

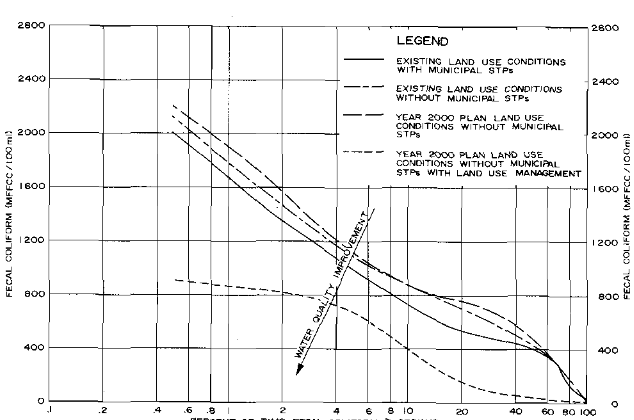
Figure 35 shows fecal coliform conditions on the Menomonee River at Hawley Road and indicates that removal of the sewage treatment plants and implementation of the year 2000 land use plan will not cause a significant change in water quality with respect to fecal coliform levels. Under year 2000 planned land use conditions, with abandonment of municipal sewage treatment plants and with implementation of land management measures, fecal coliform levels would decrease markedly so that the recommended maximum fecal coliform concentration of 400 colonies per 100 milliliters for recreational use of the surface water would be exceeded only about 10 percent of the time at this location.

Figure 36 shows fecal coliform conditions at the downstream end of the Little Menomonee River subwatershed—a portion of the Menomonee River watershed in which there are no sewage treatment plants. A comparison of fecal coliform concentration-duration curves at this location indicates that implementation of the year 2000 land use plan in the Little Menomonee River subwatershed without land management measures will cause a small change in surface water quality with respect to fecal coliform levels: a slight deterioration may be expected. Under year 2000 plan land use conditions, and with implementation of land management measures, a marked improvement in fecal coliform levels may be expected in that the recommended maximum fecal coliform concentration of 400 colonies per 100 milliliters for recreational use may be expected to be exceeded only about 5 percent of the time at this location.

Figure 37 shows the fecal coliform conditions at the discharge end of the Underwood Creek subwatershed—another portion of the watershed in which there are no municipal sewage treatment plants. A comparison of fecal coliform concentration-duration curves at this location indicates that implementation of the year 2000 land use plan will not produce a significant change in surface water quality with respect to existing fecal coliform bacteria levels. Under year 2000 plan land use conditions and with implementation of land management measures, a marked decrease in fecal coliform levels may be expected in that the recommended maximum fecal coliform concentration of 400 colonies per 100 milliliters for recreational use may be expected to be exceeded only about 9 percent of the time at this location. This fecal coliform standard is not applicable at this location since

Figure 35

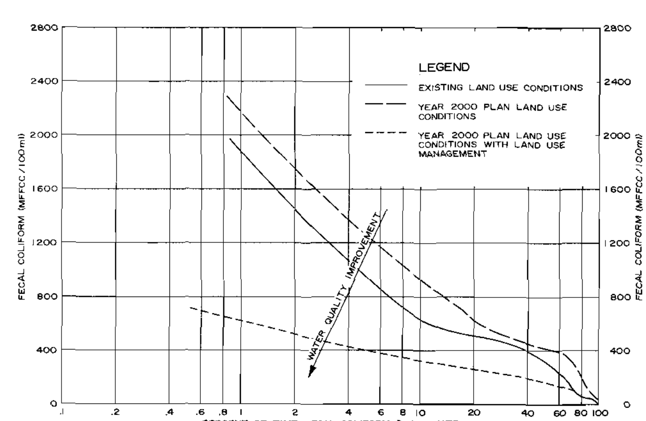
FECAL COLIFORM-DURATION RELATIONSHIPS FOR MENOMONEE RIVER AT HAWLEY ROAD



Source: SEWRPC.

Figure 36

FECAL COLIFORM-DURATION RELATIONSHIPS FOR THE LITTLE MENOMONEE RIVER AT THE MENOMONEE RIVER



Source: SEWRPC.

a restricted use objective, which has a higher maximum allowable fecal coliform concentration of 2,000 colonies per 100 milliliters associated with it, has been assigned to Underwood Creek downstream of Juneau Boulevard in the Village of Elm Grove. However, the fecal coliform count-duration relationship at the downstream end of Underwood Creek may be considered representative of what would be expected to occur along Underwood Creek upstream of the Juneau Boulevard crossing where recreation use objectives, and therefore a maximum fecal coliform count of 400 colonies per 100 ml, are applicable.

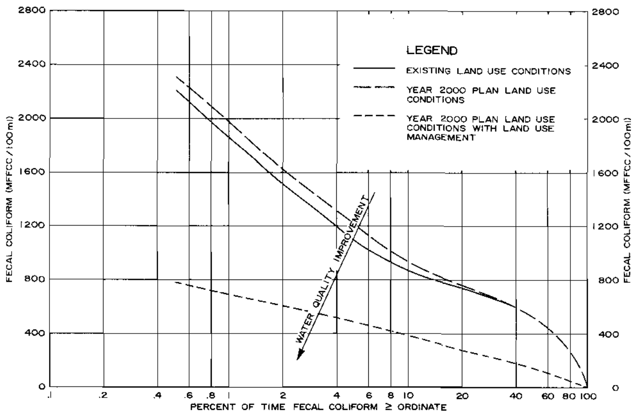
Figure 38 shows fecal coliform bacteria conditions at the discharge end of the Honey Creek subwatershed—a portion of the watershed stream system in which there are no municipal sewage treatment plants. Comparison of the fecal coliform concentration-duration curves at this location indicate that implementation of the year 2000 land use plan without land management measures will have no significant effect on fecal coliform levels. Under year 2000 plan conditions with land management measures, however, a marked improvement may be expected in that fecal coliform concentrations will not exceed the recommended maximum of 2,000 colonies per 100 ml corresponding to the restricted use objective.

Phosphate: Figure 39 shows phosphate-phosphorus conditions on the Menomonee River immediately above its confluence with the Little Menomonee River and indicates the percent of time that a specified phosphate concentration expressed as phosphorus may be expected to be reached or exceeded. Phosphate-phosphorus concentrations would be significantly altered by removal of the four upstream sewage treatment plants in that the phosphorus-duration curve at this location for existing conditions without sewage treatment plants exhibits a marked improvement over that for existing conditions with the sewage treatment plants. For example, a phosphate-phosphorus concentration of 2.0 mg/l may be expected to be reached or exceeded at this location about 40 percent of the time under existing conditions with sewage treatment plants whereas removal of the municipal sewage treatment plants would result in the concentration of 2.0 mg/l being reached or exceeded only about 2 percent of the time. Relative to the positive and dramatic impact of removing treatment plants, implementation of the year 2000 land use plan in addition to removing the sewage treatment plants will have no significant effect on phosphate-phosphorus concentrations in that the resulting phosphate-duration relationship is coincident with that for existing conditions without sewage treatment plants.

The maximum of 0.1 mg/l total phosphorus in flowing streams is the limit above which nuisance growth of algae and aquatic plants in flowing streams is expected to occur. Inasmuch as phosphate-phosphorus concentrations

Figure 37

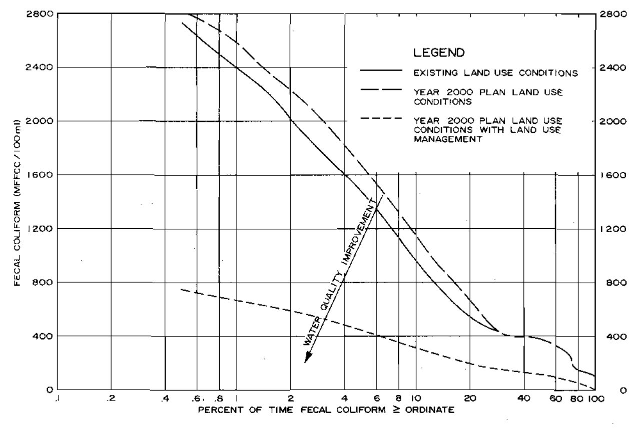
FECAL COLIFORM-DURATION RELATIONSHIPS FOR UNDERWOOD CREEK AT THE MENOMONEE RIVER



Source: SEWRPC.

Figure 38

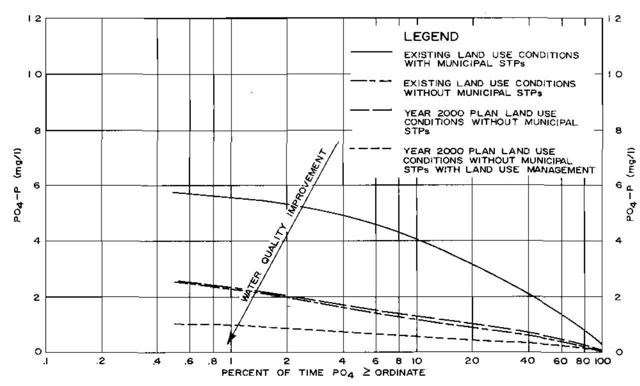
FECAL COLIFORM-DURATION RELATIONSHIPS FOR HONEY CREEK AT THE MENOMONEE RIVER



Source: SEWRPC.

Figure 39

ORTHO-PHOSPHATE-DURATION RELATIONSHIPS FOR THE MENOMONEE RIVER IMMEDIATELY UPSTREAM OF THE LITTLE MENOMONEE RIVER



Source: SEWRPC.

are approximately equal to total phosphorus levels, phosphate-phosphorus concentrations may be used to test conformance of surface water quality with the recommended standard for total phosphorus. Under existing conditions, the recommended maximum phosphorus concentration of 0.10 mg/l for prevention of nuisance growth of algae and aquatic plants may be expected to be reached or exceeded essentially all of the time on the Menomonee River at its confluence with the Little Menomonee River. A concentration of 0.5 mg/l—five times the critical level—would be exceeded over 90 percent of the time at this location. Under year 2000 planned land use conditions in combination with abandonment of municipal sewage treatment plants and application of land management measures, the recommended maximum phosphorus concentration of 0.10 mg/l for prevention of nuisance growths of algae and aquatic plants may still be expected to be exceeded almost all of the time. A marked improvement occurs, however, in that a concentration of 0.5 mg/l would be exceeded only about 10 percent of the time.

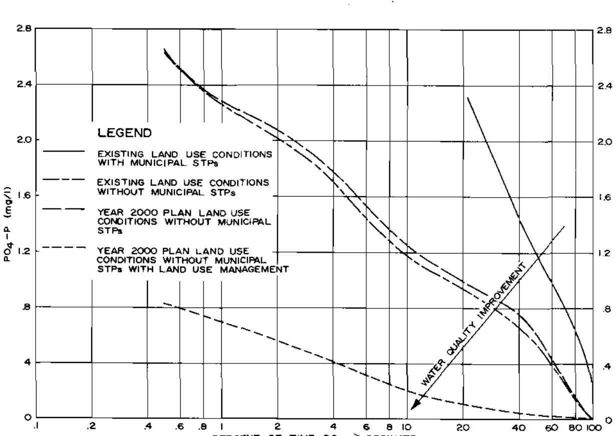
Figure 40 shows phosphate-phosphorus conditions on the Menomonee River at Hawley Road. As was the case at the upstream location, phosphate-phosphorus concentrations will be substantially reduced at these two locations as a result of removal of the four upstream sewage treatment plants and, as was also the case at the upstream location, the incremental urban development associated with the land use plan will have no significant impact on phosphate-phosphorus concentrations at this location on the Menomonee River. Under existing conditions, the recognized minimum concentration of total phosphorus of 0.10 mg/l needed to support nuisance growths of algae and aquatic plants may be expected to be exceeded essentially all of the time at this location and as would a concentration of 0.5 mg/l. Under year 2000 planned land use conditions, in combination with abandonment of municipal sewage treatment plants and application of land management measures, the recommended maximum phosphorus concentration of 0.10 mg/l may be expected to be exceeded only about 20 percent of the time. A marked improvement also occurs in that a concentration of 0.5 mg/l would be exceeded only about three percent of the time.

Figure 41 shows phosphate-phosphorus conditions on the downstream end of the Little Menomonee River subwatershed—a portion of the Menomonee River watershed in which there are no sewage treatment plants. The incremental urban development associated with the year 2000 land use plan will cause a slight deterioration in water quality with respect to existing condition concentrations whereas application of land management measures will produce an improvement in phosphate-phosphorus concentrations relative to existing conditions. Under year 2000 plannned land use conditions with land management measures, the recommended maximum total phosphorus concentration of 0.10 mg/l to prevent nuisance growths of algae and other aquatic plants would be exceeded about 50 percent of the time at this location whereas a concentration of 0.5 mg/l would be exceeded only about 3 percent of the time.

Figure 42 shows phosphate-phosphorus conditions at the outlet of the Underwood Creek subwatershed, another portion of the Menomonee River watershed in which there are no municipal sewage treatment plant discharges. A comparison of the phosphate-phosphorus duration curves indicate that the incremental urban development associated with the land use plan will, relative to existing conditions, have no significant effect on phosphate-phosphorus concentrations. Under year 2000 planned land use conditions with land management measures, the recommended maximum total phosphorus concentrations of 0.10 mg/l to prevent nuisance growths of algae and other aquatic plants would be exceeded about 50 percent of the time at this location. A concentration of 0.5 mg/l would be exceeded only about 2 percent of the time. The phosphorus standard is not applicable at this location

Figure 40

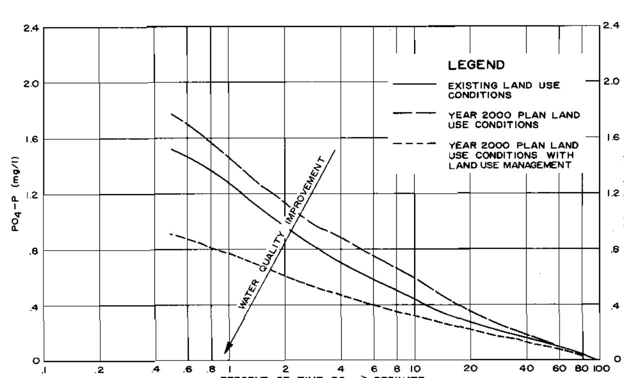
ORTHO-PHOSPHATE-DURATION RELATIONSHIPS FOR THE MENOMONEE RIVER AT HAWLEY ROAD



Source: SEWRPC.

Figure 41

ORTHO-PHOSPHATE-DURATION RELATIONSHIPS FOR THE LITTLE MENOMONEE RIVER AT THE MENOMONEE RIVER



Source: SEWRPC.

since a restricted use objective has been assigned to Underwood Creek downstream of Juneau Boulevard in the Village of Elm Grove. However, the phosphate-phosphorus-duration relationship at the downstream end of Underwood Creek, may be considered representative of that which would be expected to occur along Underwood Creek upstream of the Juneau Boulevard crossing where recreation use objectives, and therefore a phosphorus standard, is applicable.

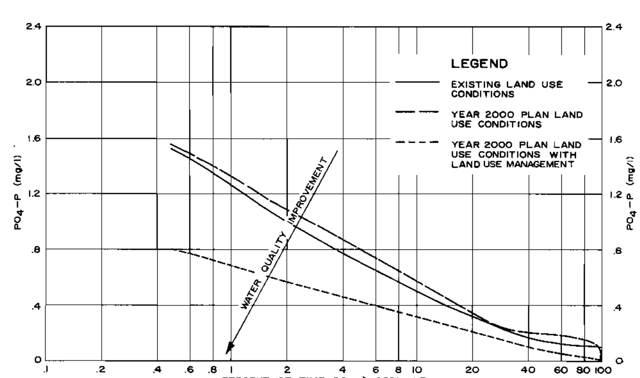
Figure 43 shows phosphate-phosphorus conditions at the discharge end of the Honey Creek subwatershed, a portion of the basin containing no municipal sewage treatment plant discharges. A comparison of the phosphate-phosphorus-duration curves indicate that the incremental urban development associated with the land use plan would cause no significant change in water quality for phosphate levels. Application of land management measures may be expected to significantly reduce phosphate-phosphorus concentrations. Other than their possible effect on the Menomonee River, phosphorus levels expected on Honey Creek are of little practical consequence since the water use objectives specify only restricted uses on this stream.

Concluding Statement—Effect of Sewage Treatment Plant Removal, the Land Use Plan, and Land Management Measures on the Concentration of Selected Constituents: Based on four continuous flow simulation runs made with the water quality submodel—existing conditions with and without the discharge of municipal sewage treatment plant effluent to the stream system and year 2000 planned land use conditions with abandonment of the municipal sewage treatment plants and with and without land management measures—the following conclusions may be drawn with respect to the concentration of selected surface water constituents:

- Surface water temperatures are not expected to be significantly affected by the abandonment of sewage treatment plants, planned urban development, or application of land management measures. Regardless of the combination of land use-pollution abatement measures that prevail, surface water temperatures may be expected to satisfy the standard—temperature of not more than 89°F for fish and aquatic life—95 percent or more of the time in those portions of the watershed stream system designated in the watershed objectives for maintenance of a warm-water fishery.
- Under existing conditions, dissolved oxygen concentrations may be expected to exceed and therefore satisfy the recommended minimum of 5.0 mg/l for fish and aquatic life about 90 percent or more of the time in those reaches of the watershed stream system designated for maintenance of a warm-water fishery. Dissolved oxygen concentrations are expected to be relatively insensitive to the abandonment of sewage treatment plants and to planned urban development. However, the application of land management measures under year 2000 planned land use conditions may be expected to improve dissolved oxygen levels so that concentrations will satisfy the recommended minimum of 5.0 mg/l for fish and aquatic life essentially all of the time in those stream reaches designated for maintenance of a warm-water fishery.
- Under existing conditions, fecal coliform concentrations may be expected to satisfy the recommended maximum fecal coliform count of 400 colonies per 100 ml for recreational use only about one-third to two-thirds of the time in those reaches of the watershed stream system designated for recreational use. Fecal coliform levels are expected to be relatively insensitive to the abandonment of sewage treatment plants and to planned urban development. However, the application of land management measures under

Figure 42

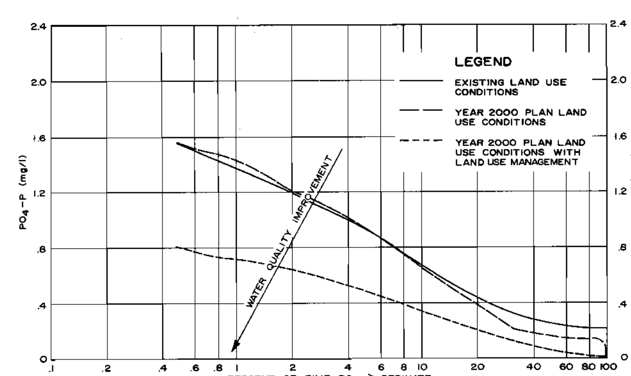
ORTHO-PHOSPHATE-DURATION RELATIONSHIPS FOR UNDERWOOD CREEK AT THE MENOMONEE RIVER



Source: SEWRPC.

Figure 43

ORTHO-PHOSPHATE-DURATION RELATIONSHIPS FOR HONEY CREEK AT THE MENOMONEE RIVER



Source: SEWRPC.

year 2000 planned land use conditions may be expected to substantially reduce the disease transmission potential of the surface waters so that the fecal coliform bacteria standard—a recommended maximum of 400 colonies per 100 ml for recreational use—may be expected to be met 90 percent or more of the time in those stream reaches designated for recreational uses.

- Under existing conditions, phosphate-phosphorus levels—which serve as an approximation of total phosphorus levels—may be expected to exceed the recommended maximum concentration of 0.10 mg/l for prevention of nuisance growths of algae and aquatic plants essentially all of the time in those stream reaches designated for recreational use and maintenance of a warm water fishery. Phosphate-phosphorus levels on the main stem of the Menomonee River may be expected to be markedly reduced with abandonment of municipal sewage treatment plants although the 0.10 mg/l concentration would still be exceeded most of the time. Phosphate-phosphorus concentrations may be expected to be relatively insensitive to planned urban development but the application of land management measures under year 2000 planned land use conditions may be expected to substantially reduce phosphate-phosphorus levels—relative to those that would exist under year 2000 planned land use conditions without land management measures. However, the recommended maximum concentration of 0.10 mg/l may still be expected to be exceeded 50 percent or more of the time in those stream reaches designated for recreational use and maintenance of a warmwater fishery. In contrast, a concentration of 0.5 mg/l— five times the recommended maximum concentration—would be exceeded 10 percent or less of the time with application of land management measures.

  It is important to note that the recommended total phosphorus standard is not likely to be achieved a large percentage of the time in southeastern Wisconsin. Based on 1968-1975 data from the SEWRPC regional water quality monitoring program, background total phosphorus levels found in natural, unpolluted headwater streams in southeastern Wisconsin approach or exceed the recommended maximum phosphate-phosphorus concentration without the impact of man's activities.

In summary, the abandonment of the four remaining municipal sewage treatment plants and application of land management measures under year 2000 planned land use conditions may be expected to markedly improve surface water quality in the Menomonee River watershed as measured by the percent of time that the concentration of critical water quality parameters will be within recommended limits. Under a full range of meteorologic, runoff, and streamflow conditions, the temperature standard may be expected to be met about 95 percent of the time, the dissolved oxygen standard essentially all of the time, and the fecal coliform standard almost 90 percent of the time. The phosphorus standard may be expected to be satisfied only about half of the time.

Results—Annual Transport: Table 40 presents the average annual transport of six selected potential pollutants at five locations throughout the Menomonee River watershed for four combinations of land use and pollution abatement measures. The six selected constituents are phosphate-phosphorus, ultimate carbonaceous biochemical oxygen demand, total dissolved solids, ammonia-nitrogen, nitrate-nitrogen, and nitrite-nitrogen. The five selected locations are: the Menomonee River immediately upstream of its confluence with the Little Menomonee River, the Menomonee River at Hawley Road in the City of Milwaukee, the Little Menomonee River at the Menomonee River, Underwood Creek at the Menomonee River, and Honey Creek at the Menomonee River. The four conditions for which average annual pollutant transport values were determined and are included in Table 40 consist of existing land use with municipal sewage treatment plants, existing land use without municipal sewage treatment plants, year 2000 planned land use without land management measures, and year 2000 planned land use with land management measures.

Table 40 permits a comparison between average annual quantity of a pollutant transported past selected points in the watershed under various conditions. This mass transport analysis is fundamentally different than the previous analysis, which was summarized in terms of water quality-duration curves, in that the mass transport analysis reflects the absolute mass of pollutants being discharged to and carried by the stream system while a quality-duration analysis focuses on in-stream pollution concentrations.

Effect of Abandoning Sewage Treatment Plants: The effect of abandonment of the four sewage treatment plants is reflected only in the simulation results for the two Menomonee River stations. Transport values set forth in Table 40 indicate that abandonment of the sewage treatment plants will substantially reduce the average annual transport of all six selected constituents at the two main stem locations. For example, the average annual transport of phosphate-phosphorus at a point immediately upstream of the confluence with the Little Menomonee at the River but downstream of the existing treatment plants may be expected to be reduced by about 80 percent from about 65,000 to 12,000 pounds per year whereas at the downstream station the transport may be expected to be reduced by about 60 percent from about 99,000 to 42,000 pounds per year. Furthermore, the average annual transport of carbonaceous biochemical oxygen demand at the upstream location may be expected to be reduced by almost 50 percent from about 476,000 to 249,000 pounds per year whereas at the downstream station the transport may be expected to be reduced by about 20 percent from 782,000 to 616,000 pounds per year.

Phosphate-phosphorus transport data for two stations on the Menomonee River indicate that the sewage treatment plants are the major source of the nutrient phosphate that is discharged to and carried by the Menomonee River. At the upstream location—the Menomonee River immediately above its confluence with the Little Menomonee River—approximately 53,000 pounds per year, or over 80 percent, of the annual phosphate-phosphorus transport is attributable to the four municipal sewage treatment plants with the remainder being attributed to washoff from the land surface during rainfall and rainfall-snowmelt events and groundwater discharge. At the downstream location—the Menomonee River at Hawley Road in the City of Milwaukee—approximately 57,000 pounds per year, or 58 percent, of the phosphate-phosphorus transport is contributed by municipal sewage treatment plants with the remainder attributed to the other sources. The downstream location exhibits a smaller percentage of phosphate-phosphorus contributed by municipal sewage treatment plants because, while both locations receive contributions from all four sewage treatment plants, the downstream location receives flow from a much larger portion of the watershed land surface—128 miles compared to 60 square miles. It is apparent, therefore, that implementation of the planned abandonment of the four municipal sewage treatment plants will significantly contribute to reducing the quantity of the troublesome nutrient phosphate transported by the Menomonee River through the watershed and into Lake Michigan.

Chapter VII, Volume 1, of this report contains a summary of a 1968-1969 study of phosphorus sources in the Menomonee River watershed which was based on an extensive field monitoring program.[14] Based on approximately one and one-half years of monitoring, that report indicates that the average annual transport of phosphate-phosphorus by the Menomonee River at about Hawley Road was 145,000 pounds per year, or approximately 50 percent more than the average annual transport results obtained from application of the water quality submodel.[15] Furthermore, that report concludes that about 40 percent of the average annual phosphate-phosphorus transported past that location, or approximately 58,000 pounds per year, was attributable to discharges from municipal sewage treatment plants. The 58,000 pound figure is approximately equal to the average annual phosphate-phosphorus attributed to the municipal sewage treatment plants based on application of the water quality submodel. The submodel, however, indicates that about 58 percent of the phosphate-phosphorus is attributable to sewage treatment plants. Finally, the report concludes that the remaining 60 percent of the average annual phosphate-phosphorus transported from the watershed, or approximately 87,000 pounds per year, was attributable to washoff from the land surface, groundwater contributions, and other sources, which is approximately double the average annual transport results obtained from application of the water quality submodel.

The differences in the results of these two independent analyses, particularly with respect to the absolute and percent contribution of phosphate-phosphorus from sources other than sewage treatment plants, may be due in part to one or both of the following factors:

1. The annual yield estimates developed under the 1968-1969 study were based primarily on 30 sets of grab sample phosphate-phosphorus determinations and recorded daily stream flows at the N. 70th Street crossing of the Menomonee River in Wauwatosa. These figures were used to calculate 30 daily transports of phosphate-phosphorus which, in conjunction with concurrent and antecedent precipitation amounts, were used to define low precipitation, high precipitation, and no precipitation periods with a unit load of phosphate-phosphorus being associated with the low and high precipitation periods. The precipitation records were then scanned to determine the number of low and high precipitation periods, and the unit loads were used to calculate the corresponding runoff of phosphate-phosphorus from the land surface. This simplified technique is likely to yield phosphate-phosphorus transport values different from those obtained with the model inasmuch as the latter employs continuous simulation and, therefore, makes direct use of the entire available meteorological record.

2. The earlier 1968-1969 study projected average annual phosphate-phosphorus transport based on data from only a one and one-half year period whereas the average annual transport estimates developed under the watershed planning program are based on the results of a 10 year simulation which is more likely to be representative of the wide range of hydro-meteorologic factors influencing washoff from the land surface.

Effect of Planned Incremental Urbanization: Compared to existing conditions without sewage treatment plants, planned urban development without the four sewage treatment plants may be expected to produce a small increase in the average annual transport of phosphate-phosphorus, carbonaceous biochemical oxygen demand, and total dissolved solids at all five locations. A slight decrease in nitrate-nitrogen may be expected, no significant change in nitrite-nitrogen may be expected, and ammonia-nitrogen may exhibit increases at three locations and decreases at two sites.

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[14] *A. Zanoni, "Eutrophic Evaluation of a Small Multi-Land Use Watershed," U. W. Water Resources Center Technical Report, June 1970.*

[15] *The referenced report expresses phosphate quantities as PO_4. Prior to use in the Menomonee River Watershed planning report, the results of the referenced report have been converted to PO_4 expressed as P so as to be consistent with the practice adopted throughout this report.*

For the two stations on the main stem of the Menomonee River, the resulting average annual mass transport of phosphate-phosphorus, carbonaceous biochemical oxygen demand, ammonia-nitrogen, nitrite-nitrogen, and nitrate-nitrogen will be less than that expected under existing conditions with sewage treatment plants, while the resulting transport of total dissolved solids will exceed that for existing conditions with sewage treatment plants. The net effect on the Menomonee River of the abandonment of the sewage treatment plants and additional urban development is an up to 70 percent reduction in the annual transport of five of the six selected constituents and an increase of up to 15 percent in total dissolved solids.

Effect of Land Management Measures: Relative to both existing conditions with sewage treatment plants and to year 2000 land use plan conditions with abandonment of sewage treatment plants, the application of land management measures will generally achieve a substantial reduction in the mass transport of all pollutants at all five selected locations on the watershed stream system. Considering all five locations, the average annual transport of phosphate-phosphorus will be reduced, relative to existing conditions, by from about 45 to 90 percent; carbonaceous biochemical oxygen demand by from about 45 to 80 percent; and total dissolved solids by from about 35 to 50 percent. More specifically, at the Hawley Road crossing of the main stem of the Menomonee River, application of land management measures under year 2000 planned land use conditions, when compared to existing conditions with sewage treatment plants, may be expected to: reduce the average annual transport of phosphate-phosphorus by about 90 percent, from about 99,000 to 10,000 pounds per year; reduce carbonaceous biochemical oxygen demand transport by about 65 percent, from about 780,000 to 275,000 pounds per year; reduce total dissolved solids transport by about 45 percent, from about 140 to 80 million pounds (70,000 to 40,000 tons per year); reduce ammonia-nitrogen transport by about 90 percent, from about 480,000 to 50,000 pounds per year; and reduce nitrate-nitrogen transport by about 90 percent, from about 300,000 to 30,000 pounds per year.

Concluding Statement—Effect of Sewage Treatment Plant Removal, the Land Use Plan, and Land Management Measures on the Transport of Selected Constituents: Based on four continuous simulation runs made with the water quality submodel—existing conditions with and without the discharge of municipal sewage treatment plant effluent to the stream system and year 2000 planned land use conditions with abandonment of the municipal sewage treatment plants and with and without land management measures—the following conclusions may be drawn with respect to the annual transport of selected surface water constituents:

- Existing municipal sewage treatment plants contribute from 60 to 80 percent of the phosphate-phosphorus and from 20 to 50 percent of the carbonaceous biochemical oxygen demand transported by the Menomonee River. Therefore, implementation of the planned abandonment of these treatment plants will substantially reduce the quantity of these two critical pollutants carried by the Menomonee River through the watershed and into Lake Michigan.

- Planned incremental urban development by the year 2000 may be expected, relative to existing conditions without sewage treatment plants, to produce a small increase in the average annual transport of most surface water pollutant constituents including the potentially troublesome phosphate-phosphorus and carbonaceous biochemical oxygen demand.

- Land management measures applied to year 2000 planned land use conditions, in combination with abandonment of sewage treatment plants, may be expected, relative to existing conditions with sewage treatment plants, to markedly reduce the average annual transport of most surface water constituents. For example, the average annual transport of phosphate-phosphorus may be expected to be reduced up to 90 percent; carbonaceous biochemical oxygen demand up to 80 percent; and total dissolved solids up to 50 percent.

Two requisites for a desirable fishery in a river system are adequate water quality and adequate flow. Data presented in Chapter IX, Volume 1 of this report, indicate that the fishery of the watershed has been significantly diminished due primarily to water quality deterioration as urban activities have increased in the watershed. The watershed currently supports a minimal recreational fishery characterized by the dominance of fish species that are generally tolerant to poor water quality. An improvement in water quality conditions may be expected to result in a more desirable fishery provided that low flow levels are adequate. The enhancement of surface water quality in the watershed could also supply the basis for the improvement of fishing opportunities either by natural reproduction or through supplemental fish stocking and other management measures. In particular, there is the potential in the lower portions of the watershed for the development of a anadromous fishery, that is, a fishery whose species instinctively migrate from Lake Michigan up tributary streams for the purposes of spawning. The development of such a fishery, however, will also depend upon the improvement in the harbor estuary of water quality conditions which at present are a deterrent to the upstream movement of anadromous fish.

The committed water pollution control measures in combination with land management measures should, as described in this chapter, lead to a substantial improvement in stream water quality. At the same time, however, the committed abandonment of the four municipal sewage treatment plants operating within the watershed will further reduce low flow to critical levels for sport fish species. Therefore, it is unlikely that a high value, perennial, self-sustaining recreational fishery can be developed throughout the watershed stream system, even if water quality conditions are dramatically improved because of the extremely low flow conditions that are likely to occur periodically in the headwater areas of the watershed. It is important to point out, however, that a substantial improvement in water quality will create a habitat for a diverse population of the smaller, non-sport fish species such as minnows and invertebrates. Those species will provide a significant opportunity for outdoor-class study and observation.

The low probability of the development of a natural sport fishery of high value throughout the watershed does not, however, negate the desirability of and the need for the implementation of measures to substantially reduce surface water pollution in the watershed. In fact, next to human health considerations, the principal value of abating the serious surface water pollution problems of the watershed is to provide an aesthetically pleasing stream system which is basic to a high quality expanded park and parkway system required for a wide variety of active and passive outdoor recreational activities in riverine areas. A reasonably clean and aesthetically pleasing stream is necessary to, although not sufficient for, the full enjoyment of outdoor recreational activities in riverine areas. Furthermore, the desirability and stability of both new urban development anticipated in the watershed during the next two or three decades and of existing urban development will benefit from adjacent attractive riverine area parks and parkways and natural areas which are enhanced by a high quality stream.

In summary, a high value, perennial, and self-sustaining watershedwide sport fishery is unlikely to develop in the watershed even if substantial improvements are made in surface water quality. However, the opportunity for full enjoyment of active and passive outdoor recreational opportunities throughout the basin and the achievement of public health considerations necessitate a substantial improvement in the quality of the surface waters in the Menomonee River watershed.

The primary environmental corridor subelement of the land use plan, as described in Chapter III of this volume, includes a recommendation for the application of sound management techniques to all woodland, wetland, and wildlife habitat areas in the watershed and, in particular, those located within the primary environmental corridors. In accordance with that recommendation, it may be feasible to further enhance fishery opportunities within the Menomonee River watershed—assuming improvement in water quality conditions—by implementation of modest localized management measures intended to enhance fish and wildlife habitat along the streams. For example, very low head dams or sills could be constructed on the stream system to compensate in part for low flow conditions, to lead to the development of emergent vegetation necessary for good fish and wildlife habitat, to enhance stream reaeration, and to provide for entrapment of sediment. Development of such natural wildlife habitat areas could be accomplished in those portions of the watershed stream system that are not now channelized or recommended for channelization and that do not have extremely steep slopes. Examples of riverine areas that may be suited to development of or enhancement of modest wildlife habitat areas include Underwood Creek between Santa Maria Court and W. North Avenue in the City of Brookfield and the Menomonee River north of the Waukesha-Milwaukee County line in the Village of Germantown.

The development of natural areas along the surface water system would most appropriately be initiated by local governmental units such as villages or cities or by the county park agencies and could be carried out with the technical assistance of the Wisconsin Department of Natural Resources.

MEASURES FOR REDUCING THE WASHOFF OF POLLUTANTS FROM THE LAND SURFACE TO THE STREAM SYSTEM

The preceding sections of this chapter have established, through use of the simulation model, that a substantial improvement in surface water quality can be achieved under year 2000 land use plan conditions through: 1) abandonment of the four remaining municipal sewage treatment plants in the Menomonee River watershed and 2) a 50 percent reduction in the land surface accumulation rates of various potential pollutants and in the concentration of such pollutants in groundwater as a result of the implementation of land management measures. More specifically, low flow analyses indicate that, under late summer 7-day 10-year low flow conditions, implementation of the above measures may be expected to yield surface water temperature, dissolved oxygen content, fecal coliform levels, phosphate-phosphorus concentration, and ammonia-nitrogen levels that permit recreational use and maintenance of fish and aquatic life along the main stem of the Menomonee River as set forth in the watershed objectives.

A continuous flow simulation analysis indicates that implementation of the above water quality control measures may be expected to result in achievement of the temperature standard about 95 percent of the time, the dissolved oxygen standard essentially all of the time, and the fecal coliform standard almost 90 percent of the time. The phosphorus standard cannot be satisfied a high percentage of the time since regional surface water quality surveys reveal that the total phosphorus level in natural headwater stream areas approaches or exceeds the recommended maximum phosphate-phosphorus concentration without the impact of man's activities. The continuous flow simulation analysis also indicates that implementation of the above measures may be expected to result in a 90 percent reduction in the transport of phosphate-phosphorus in the lower reaches of the Menomonee River, a 65 percent reduction in the transport of carbonaceous biochemical oxygen demand, and a 45 percent reduction in total dissolved solids.

The purpose of this section of the chapter is to identify and briefly describe practical land management measures capable of achieving the necessary one-half reduction in the rate at which potential pollutants accumulate on the rural and urban land surfaces of the Menomonee River watershed with subsequent similar reduction in transport of pollutants from the land surface to the watershed stream system. There are two overall approaches available for abatement of diffuse source pollution—the source approach in which measures are applied to reduce the rate at which potential pollutants accumulate on the land surface prior to washoff to the streams and the treatment approach in which potential pollutants are removed from storm water runoff before it enters the surface water system. Estimates of the likely cost of implementing the necessary land management measures are also presented. The discussion of land management measures is presented in three parts: *control of feedlot runoff, control of runoff from agricultural land, and control of runoff from urban lands.*

Land management measures are closely related to land use in that there is one set of land management measures generally suitable for agricultural lands and another set of land management measures generally suitable for urban lands. Land use within the watershed is dynamic in that the year 2000 land use plan calls for the gradual conversion of 15 square miles of presently rural land to urban development. Inasmuch as it is difficult to determine precisely the rate and spatial sequence at which this conversion will occur within the watershed and inasmuch as the application of land management measures should begin immediately, it was assumed, for purposes of analysis, that the land management measures would be applied under existing (1970) land use conditions. That is, the estimated capital and operation and maintenance costs of applying the land management measures assume the existing amount and location of rural and urban land in the watershed. Although this approach is the most reasonable in light of the unknown spatial and temporal transition from rural to urban land uses, it does not fully represent the total cost of land management measures. For example, the resulting cost of applying land management measures to the watershed does not reflect the fact that some areas in the watershed currently in rural use may have rural type land management measures applied to them in the near future and then, when they are developed for urban uses, it may be necessary to apply, at additional cost, a different set of land management measures probably consisting of temporary measures during construction and development and permanent measures subsequent to development. It may be argued, however, that the costs of land management measures required for new urban development should be properly considered part of the cost of such development and, therefore, are not chargeable to the water quality management plan element of the comprehensive watershed plan.

Control of Feedlot Runoff

As described in Chapter VII, Volume 1 of this report, a large number of animal husbandry operations exist in the Menomonee River watershed, most of them located in the Washington and Ozaukee County portions of the basin. More specifically, a 1976 inventory conducted by the Commission revealed that there are 42 dairy cattle operations, four beef cattle operations, and three hog operations, for a total of 49 animal operations with a total of about 2,600 animals. These estimates of the number of animal operations and the total number of dairy cattle, beef cattle and pigs are conservative inasmuch as the inventory conducted to obtain the data considered only animal operations of 20 head or larger.

All 49 animal husbandry operations use barnyards and, as also described in Chapter VII in Volume 1 of this report, 12 barnyards or 25 percent of the total have a hydraulic distance from the nearest well-defined stream of 500 feet or less; 17 barnyards or 35 percent of the total are within 1,000 feet; and 36 barnyards or about three-fourths of the total are within 2,000 feet or less. A well-defined water course is herein defined as a natural stream or an artificially constructed channel that usually contains water and is clearly evident on a 1" = 400' scale aerial photograph. Few, if any, of the barnyards or feedlots have been provided with effective facilities to control runoff from the feedlots or to handle and properly dispose of the solid and liquid waste that accumulates there (see Figure 44).

If the established water use objectives are to be achieved and if the overall quality of the environment is to be improved, pollution control measures should be applied to the animal husbandry operations in the Menomonee River watershed. Water quality monitoring, as described in Chapter VII, Volume 1 of this report, reveals high fecal coliform counts and phosphate concentration in the headwater portions of the watershed along with low dissolved oxygen levels, all of which must be in part attributable to feedlot runoff. In addition, aesthetic problems exist in the form of odor and heavy growths of algae and aquatic plants in and near the creeks and streams receiving runoff from the feedlots.

It was assumed that some combination of runoff control measures would be applied to each feedlot requiring improvement. For example, an upper earthen berm or drainageway could be constructed above the feedlot to divert upland storm water around the lot thereby reducing the washoff of solid and liquid wastes from the barnyard to the receiving streams. A lower earthen berm or a curb around the periphery of the feedlot could serve to trap solid and liquid wastes from the feedlot and permit their safe disposal without transport to local surface waters. The feedlot could be shaped and perhaps paved so as to provide good surface drainage and could be enlarged as needed to provide adequate size. An open concrete storage facility and a holding pond having sufficient volume to store at least 120 days of liquid and solid waste could be provided. Supplemental equipment, such as a manure stacker needed to move solids to the storage facility and equipment needed to remove the stored material prior to disposing of it by land application, could be obtained and used. A feasible feedlot runoff control system is shown in Figure 45 and is intended to illustrate one of the many systems that could be developed, depending on site conditions and existing facilities, to control feedlot runoff.

The average capital cost of applying feedlot control measures to a given animal operation is estimated at about $10,000. This unit cost per feedlot includes actual construction cost plus allowances for design,

Figure 44

TYPICAL ANIMAL BARNYARDS AND FEEDLOTS IN THE MENOMONEE RIVER WATERSHED

Animal feeding operations are a potential source of water pollution in the Menomonee River watershed. Barnyards located on small streams such as shown below permit liquid and solid wastes from livestock to enter the surface water system resulting in organic, nutrient, pathogenic, and aesthetic pollution. Note that in both of these cases the livestock have direct access to the stream and have trampled the stream banks and adjacent areas.

Source: SEWRPC.

administration, and contingencies. An operation and maintenance cost was not assigned to feedlot runoff control facilities inasmuch as operators of barnyards must periodically remove accumulated solid and liquid waste from the yards and dispose of it by application to crop or pasture lands. Assuming that such feedlot pollution control measures are applied to 40 animal operations, or about 80 percent of the total, in the Menomonee River watershed the total capital cost for feedlot runoff control for the Menomonee River watershed is about $400,000.

The above analytic approach is sufficient to provide a good estimate of the overall cost of resolving the feedlot pollution problems in the Menomone River watershed. It is important to recognize, however, that implementation of such measures will require the proper adaption of the most suitable set of measures to each feedlot. Technical assistance in selecting and designing feedlot pollution control measures is available through the U. S. Department of Agriculture, Soil Conservation Service. Financial assistance for implementation may be available through the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service.

Control of Runoff from Agricultural Land

As indicated in Chapter VII, Volume 1 of this report, an examination of May 1975 aerial photographs and a field reconnaissance indicate almost complete absence of land management measures on agricultural lands in the upper Menomonee River watershed. More specifically, basic, low cost agricultural land management techniques such as contour plowing and strip cropping are used very little in the Menomonee River watershed.

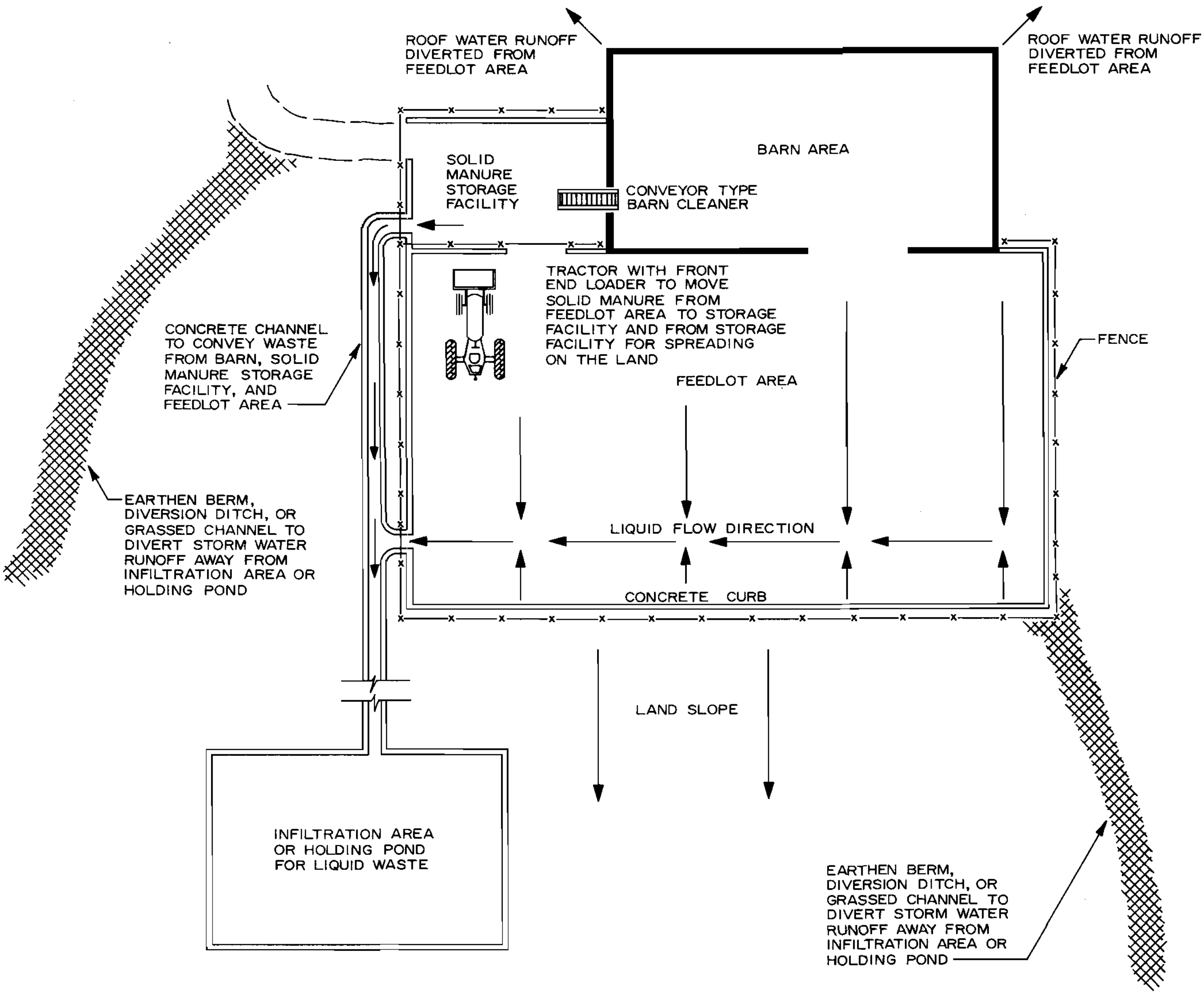
The above conclusions concerning the lack of basic land management practices on agricultural lands in the Menomonee River watershed are substantiated by the results of a 1976 Commission inventory of conservation practices funded by the Agricultural Stabilization and Conservation Service, U. S. Department of Agriculture, in the Menomonee River watershed over approximately the past decade. As discussed in Chapter VII of Volume 1, such conservation measures have been applied to a total of less than one-half square mile, or less than 1 percent of the agricultural land in the Menomonee River watershed over that period. Therefore, in spite of the availability of technical and financial support from the federal government for application of conservation and land management measures to agricultural lands, voluntary efforts have achieved little in the implementation of such measures in the Menomonee River watershed.

The failure of achieving on a voluntary basis significant implementation of basic land and water conservation measures on agricultural lands in the Menomonee River watershed may be attributable, in part, to the anticipated high potential for conversion of these agricultural lands to urban land uses in the relatively near future.

Potential pollutants such as sediment, phosphorus, and organic material move from agricultural lands to the surface waters almost exclusively by surface runoff. Phosphates in particular are believed to be adsorbed by soil colloids and moved from the agricultural lands into the streams through erosion of the surface soil. Much of the phosphorus washoff occurs during spring snowmelt and rainfall runoff periods and is attributable to manure being spread on frozen ground throughout the

Figure 45

TYPICAL FEEDLOT RUNOFF CONTROL SYSTEM



Source: University of Wisconsin Extension and SEWRPC.

preceding winter. However, phosphorus, manure, and other potential pollutants also may be transported to the surface waters at other times of the year during runoff events. Elimination of the practice of spreading manure on frozen ground, as would be accomplished through implementation of the above-described feedlot pollution control measures, and good soil conservation practices that prevent erosion are effective complementary means of controlling pollution from agricultural land.

Two alternative approaches for control of erosion and, therefore, for control of pollution from agricultural lands, were considered. One was the use of the basic land management measures such as contour plowing, strip cropping, and minimum tillage, and the other was the use of bench terracing.

Contour Plowing, Strip Cropping, and Minimum Tillage: In a situation such as the Menomonee River watershed, where agricultural operations are being conducted largely without the use of the basic conservation practices, such measures as contour plowing, strip cropping, and minimum tillage generally may be expected to achieve a 50 percent reduction in erosion from the land surface to the surface water system. If minimum tillage is accomplished with the use of herbicides and other chemicals, caution must be exercised to assure that these substances do not wash off the agricultural lands and degrade surface water quality. An initial or capital cost is normally associated with implementation of these measures reflecting, in part, the cost of preparing a conservation plan for a given farm and the cost of moving fences and vegetation as needed to permit altering the manner in which the land is plowed and worked. While the initial unit capital cost of contour plowing, strip cropping, and minimum tillage is quite site-specific and may be expected, therefore, to vary widely, the cost may be expected to be less than $10 per acre. Therefore, for purposes of developing an estimate of the cost of applying basic conservation measures to agricultural lands in the Menomonee River watershed, it was assumed that such measures could be implemented at a unit capital cost of $10 per acre. No annual operation and maintenance costs were assigned to the land management measures since it was assumed that, if such incremental costs were incurred, they would be negligible relative to annual field costs already incurred in the farming operation or would be offset by increased crop yields.

In 1970 there were about 44.5 square miles of cropland and pasture in the Menomonee River watershed. It was assumed that contour plowing, strip cropping, minimum tillage, or various combinations of these would be applied to that portion of the agricultural and pasture land having a slope of 2 percent or more. It is recognized that the detailed design of land management practices on a field by field basis must consider factors other than degree of land slope, such as slope length, soil type, and crop type. However, the use of a 2 percent slope criterion is considered adequate for identifying the approximate areal extent of crop and pasture land in the watershed that may require basic land and water conservation measures. Based on the 2 percent slope criterion, basic land management measures would be required for 36 square miles or 80 percent of the total amount of agricultural and pasture land in the watershed. The total cost of implementing these land management measures at $10 per acre would be $230,400. The approximate spatial extent of agricultural and pasture lands that would require contour plowing, strip cropping, or minimum tillage or combinations of these measures is shown on Map 49.

Bench Terraces: The construction of bench terraces on land subject to erosion will furnish almost complete erosion control. A typical cross-section of a bench terrace slope is shown in Figure 46. A bench terrace is defined as a small earth fill constructed across a field slope to store runoff and release it slowly to the soil through underground drainage tiles. Such bench terraces are also known as blind tile outlet terraces. The earth fill provides a barrier for temporarily impounding surface runoff and collecting the eroded soil so that the combination of soil pushed into the earthfill and the collected soil produces a flat slope—thus, the name bench terrace.

Bench terraces are constructed by pushing up earth borrowed from the downhill side. The downhill sides of the fill slopes are usually constructed at a slope of one vertical to two feet horizontal and are seeded to grass. The uphill slope of the earth fill is proportioned to fit modern farming equipment. The storage fills or terraces are normally constructed with a bulldozer although a carryall scraper is more efficient if extensive, long distance, lateral movement of earth is required. Tile can be installed with conventional agricultural drainage equipment.

Bench terraces are capable of trapping over 90 percent of the sediment runoff from cultivated lands and essentially all of the phosphorus, manure, and other potential pollutants associated with such sediment. In addition, bench terraces put more water into the soil by encouraging ponding and infiltration, retain the nutrients on the land to improve crop production, and may eliminate the need for some large manure holding tanks.

Originally, bench terraces were used only for deep soils since exposure of less productive subsoils during the construction of the terraces was not a problem in such soils. Where exposed subsoil might seriously depress yields, a bench terrace system can be developed by stripping and temporarily storing the top soil in borrowed areas, constructing the terraces, and then replacing the top soil. Excess water stored on the bench terraces is drained off through underground conduits usually made of field drain tile, as shown in Figure 46. The water enters the underground tile conduits so that some is percolated or filtered through the soil, allowing adsorption of phosphates. The tile inlets are sized to carry 1" runoff in 24 hours, thus retarding peak inflows. This retardation allows sediment to settle out and, in so doing, traps over 90 percent of the sediment in the storage area while providing good agricultural drainage.

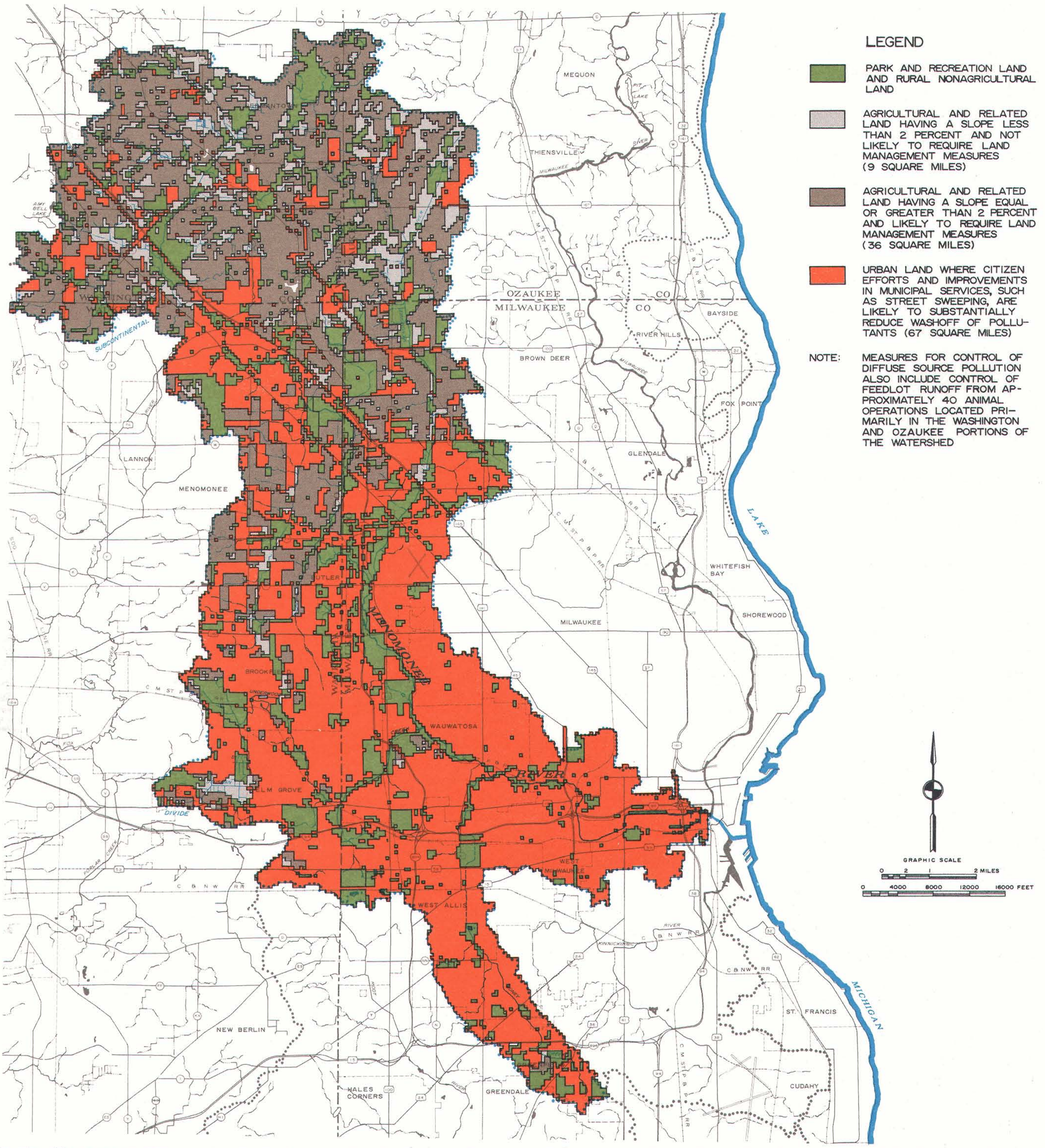
Terrace costs increase with slope, since the steeper slopes require higher earth fills for storage, and the terraces must be spaced closer together. The cost of constructing the bench terraces must also include allowance for the underground tile system. For purposes of estimating the cost of applying terraces to the agricultural land in the Menomonee River watershed, a unit capital cost of $200 per acre was assumed which includes design and construction cost plus an allowance for contingencies.

As was true with contour plowing, strip cropping, and minimum tillage, it was assumed for gross cost estimating purposes that bench terraces would be applied to all agricultural land having a slope of 2 percent or more. The capital cost of applying bench terraces to 36 square miles of such land is estimated at $4,608,000.

Concluding Statement—Recommended Measures for Control Runoff from Agricultural Land: The above analysis indicates that basic land conservation measures such as contour plowing, strip cropping, and minimum tillage can be applied to that 80 percent of the 44.5 square miles of agricultural land in the Menomonee River watershed having a slope of 2 percent or more for a capital cost of about $230,000. The application of such measures may be expected to achieve the desired 50 percent reduction in erosion from those presently unprotected lands. The above analysis also indicates that, as an alternative, bench terraces could be constructed on that 36 square miles of agricultural land in the Menomonee River watershed for a capital cost of $4,608,000. In contrast with the approximately 50 percent reduction in erosion that would be achieved as a result of the application of contour plowing, strip cropping, and minimum tillage, the construction of

Map 49

AREA OF THE WATERSHED FOR WHICH LAND MANAGEMENT MEASURES ARE RECOMMENDED FOR CONTROL OF DIFFUSE SOURCE POLLUTION

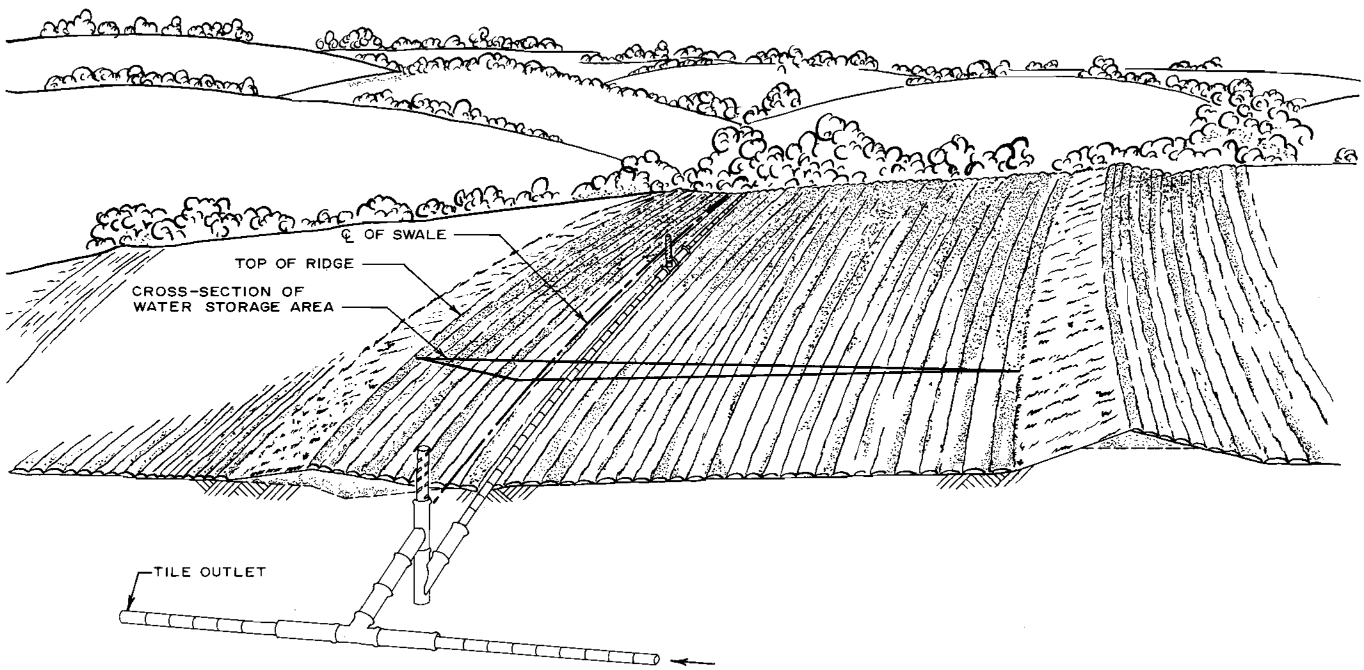


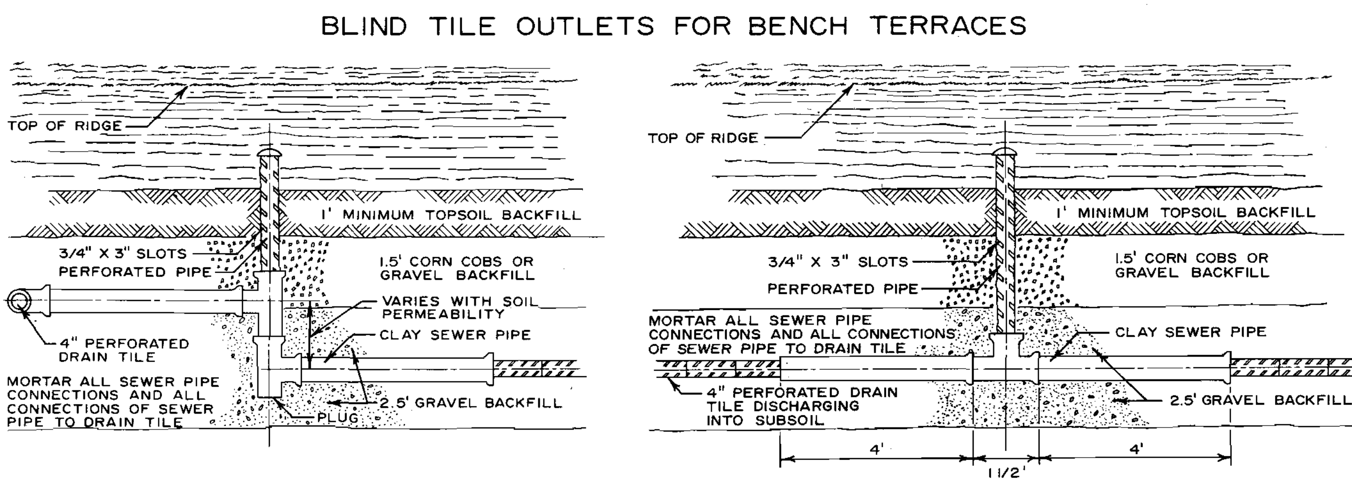
In the Menomonee River watershed, where agricultural operations are being conducted largely in the absence of good basic soil and water conservation practices, application of measures such as contour plowing, strip cropping, and bench terracing may be expected to achieve an approximately 50 percent reduction in the washoff of sediment and associated pollutants from the agricultural land to the surface water system. The watershed plan recommends application of basic conservation practices to the 36 square miles of crop and pasture land in the watershed having a slope of 2 percent or more indicated on the map above.

Source: SEWRPC.

Figure 46

TYPICAL BENCH TERRACE CROSS SECTION





Source: U. S. Soil Conservation Service and SEWRPC.

bench terraces could be expected to achieve a 90 percent reduction in erosion from the agricultural land and a similar reduction in the contribution of pollutants such as phosphorus and organic material in washoff from the agricultural lands. However, the capital cost associated with the construction of bench terraces is approximately 20 times the capital cost associated with the implementation of a system of contour plowing, strip cropping, and minimum tillage. Inasmuch as the incremental benefits attendant to the use of bench terraces relative to basic conservation measures are not likely to justify the twenty-fold increase in cost, it is recommended that contour plowing, strip cropping, and minimum tillage be used as the basic means of controlling runoff from agricultural lands in the Menomonee River watershed. It is recognized, however, that in implementation of this recommendation there may be locations in the Menomonee River watershed for which the construction of bench terraces may be warranted such as in areas having very steep slopes. On individual farmsteads, the optimum package of land management measures may consist of the more costly bench terraces applied to only a small portion of the agricultural land, based on an examination of factors such as length and degree of slope and type of soil, with other low cost measures being applied to some or all of the remaining agricultural lands.

As indicated in Table 39, there are other land management measures available for control of diffuse source pollution in agricultural areas including careful application of chemical fertilizers, maintenance of greenways along streams, development of grassed waterways, and construction of detention dams. Use of these potentially useful land management measures as supplements to and perhaps partial replacements for the recommended contour plowing, strip cropping, and minimum tillage measures should be considered in the planning of a land management program for each given farming operation. Technical and financial assistance in the design and implementation of a land management program for a given farm are available from the U. S. Department of Agriculture, Soil Conservation Service, and Agricultural Stabilization and Conservation Service and from the local Soil and Water Conservation Districts. Based on a consideration of factors such as land slope, length of slope, soil type, and desired crops, these agencies can design an optimum combination of land management measures for a given farm operation so as to accomplish the dual purpose of increasing the productivity of the farm while protecting surface water quality.

Control of Runoff from Urban Lands

Characteristics of Available Diffuse Pollution Control Measures:

Diversity of Sources and Solutions: With respect to resolution of the diffuse source pollution problem, urban areas have two characteristics that differ from rural areas and complicate preparation of a diffuse source pollution abatement subelement for urban areas. First, because man, his structures, and his activities dominate the urban portion of the watershed, there are many more ways in which diffuse source pollution is generated in an urban area and, likewise, many more measures available to mitigate that pollution. For example, the existence of a storm sewer system which collects storm water runoff and conveys it, perhaps after temporary storage, to an outfall pipe for discharge to the surface waters provides an opportunity for storm water treatment at the collection point, at the storage site, or at the outfall to remove potential pollutants from the storm water before discharge to the streams. An analgous situation does not generally exist in rural areas.

Availability of Low or No-Cost Solutions: The second unique characteristic of the urban environment with respect to the control of diffuse sources of pollution is the fact that many of the pollution control measures can be accomplished at little or no cost. In many cases, the basic requirement is cooperative efforts by an enlightened public. Some of these little or no-cost measures are: attempted control of littering by domestic animals either voluntarily or by ordinance; proper application of chemical and organic fertilizers and pesticides to lawns, golf courses, and parkland; control of litter and debris on private property by voluntary action or by ordinance; control of litter in public areas by provision of ample trash receptacle areas and through strict enforcement of anti-litter ordinances; sediment and debris control during demolition and construction activities; and proper material storage.

It may be possible to improve the efficiency of such municipal services as street cleaning and maintenance, street de-icing, and garbage collection—all of which affect the diffuse source pollution problems in urban areas—without a significant increase in costs by concentrating on finding more efficient ways to carry out these functions within existing budget constraints. For example, an analysis of hypothetical ways to conduct a street cleaning operation by varying factors such as the frequency of cleaning and the number of passes made per cleaning and by considering prohibition of parking in selected areas one day a week to permit better access to the curb area indicated that a substantial reduction in the average quantity of dust and dirt left on the streets could be achieved with no significant additional increase in cost as a result of finding a better combination of factors.[16]

Detention or retention storage of storm water may provide another low or no-cost solution to the diffuse source pollution problems in existing or developing urban areas. A detention reservoir is a storm water storage facility that is normally dry, or contains very little water, and is designed to fill during storm water runoff events thereby significantly attenuating downstream storm water flows and permitting the reduction in the size and, therefore, the cost of downstream storm water channels or sewers. After the passage of the storm water runoff event, the detention reservoir is drained by gravity or by pumping. A retention reservoir, in contrast, is a storm water storage facility that normally contains a substantial volume of water, at a predetermined conservation pool level, that is available for recreational activities or for aesthetic purposes, above which a a storm water runoff storage volume is maintained for utilization during runoff events. The principal purpose of storm water detention or retention reservoirs is to control storm water runoff so as to prevent local flooding at a cost that is less than that required for a conventional storm water system employing large open channels or conduits. Although the use of detention-retention storage in urban storm water control systems is relatively new compared to the traditional underground storm water systems, enough experience has been gained with the storage concept to demonstrate that it can be a more economical means of handling storm water runoff.[17] A second positive aspect of storm water detention or retention storage is the recreational benefits or multiple uses that can be achieved with these facilities. For example, in the case of detention reservoirs which are normally dry, the site can be used for park and outdoor recreation purposes such as playing fields and picnicking areas, whereas in the case of a retention reservoir which normally contains water, the site can provide for water-

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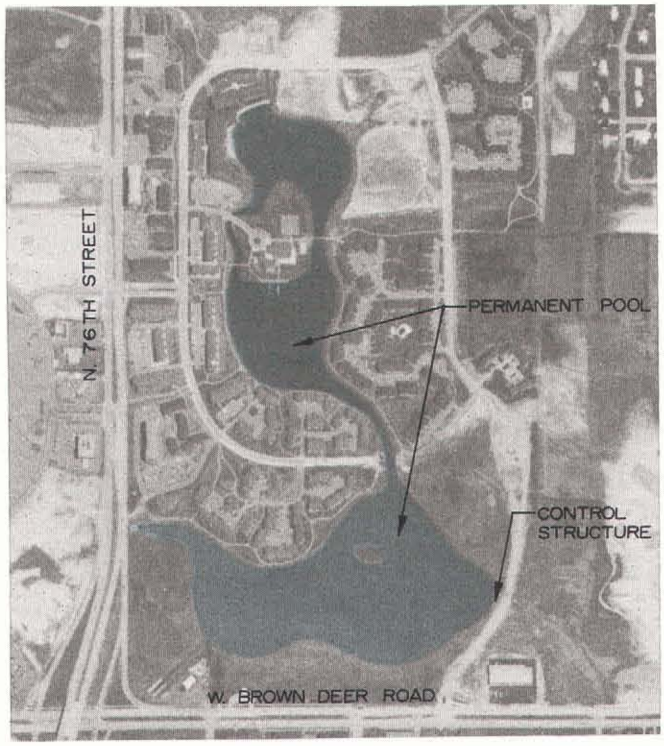
[16] *American Public Works Association and the Federal Water Pollution Control Administration, Water Pollution Aspects of Urban Runoff, Section 7, "Cost of Prevention and Treatment," June 1969, pp. 145-149.*

[17] *H. G. Poertner, "Better Storm Drainage Facilities at Lower Cost," Civil Engineering-ASCE, October 1973, pp. 67-70.*

oriented recreational activities such as wading or boating while also having aesthetic values. A third positive aspect of detention-retention storage is treatment, through plain sedimentation, of storm water runoff prior to its discharge to the surface water system. That is, the temporary storage of storm water runoff in the detention or retention reservoir provides an opportunity for suspended material to settle out carrying with it some of the potential pollutants. A recently completed research investigation concluded that 15 minutes of quiescent settling of urban land runoff could remove 50 percent of the turbidity, 60 percent of the chemical oxygen demand, and 77 percent of the suspended solids.[18] Because detention or retention reservoirs function well as sediment traps, it may be necessary to periodically remove accumulated sediment. The reservoir may be designed so as to concentrate sediment deposition at points of entry thereby simplifying the periodic sediment removal work. A good example of a retention reservoir within the Region that performs all three of the above functions—control of storm water runoff, provision of recreational opportunities, and enhancement of water quality—is shown in Figure 47. This is the retention reservoir within the Northridge development which is located immediately east of the Menomonee River watershed on Brown Deer Road in the City of Milwaukee. In summary, then, storm water detention or retention reservoirs may provide a low cost means of substantially reducing the transport of potential pollutants from urban land surfaces to the stream system in addition to providing for storm water control and providing recreational facilities.

Figure 47

RETENTION RESERVOIR AT THE NORTHRIDGE DEVELOPMENT IN THE CITY OF MILWAUKEE



Source: SEWRPC.

Cost Estimate: Because of the above two characteristics of diffuse source pollution control in urban areas—the diversity of measures that may be available and the likelihood that many measures can be applied at little or no cost—and because of the site-specific nature of the application of such control measures, it is difficult to develop a definitive diffuse source pollution control subelement for the urban portions of the Menomonee River watershed. Development of a diffuse source pollution control subelement would require a detailed analysis of the sources of pollution—literally on a block-by-block basis—and the alternative means of controlling it. Such a detailed investigation is beyond the scope of the comprehensive watershed planning program.

However, in order to estimate the likely cost of the improved control over diffuse source pollution in the urban areas of the watershed, the cost of improved application of street sweeping—an effective, widely used technique—was determined. It was assumed that surface contamination washoff from the urban land surface to the stream system travels via the streets so that a 50 percent reduction in the average amount of material remaining on the streets would be equivalent to the desired 50 percent reduction in land surface accumulation rates. Normal street cleaning operations achieve an approximately 50 percent reduction in the amount of material remaining on the streets. The effectiveness of street cleaning can be easily improved to a total of 75 percent reduction—that is, an incremental reduction of 50 percent—by one or more additional measures including making two passes per sweeping operation rather than one, using wire brushes on the street sweeper, reducing the forward speed of the sweeper unit, increasing the brush speed, increasing the frequency of street cleaning operations and using vacuum type sweepers.[19]

A review of street sweeping costs for communities in and near the Menomonee River watershed indicates that the unit cost of street sweeping is approximately $10 per acre of urban land per year. Approximately 90 percent of this cost is for operation and maintenance purposes and the remaining 10 percent is for amortization of capital expenditures. It was assumed that the desired improved application of street sweeping would approximately double the cost of street sweeping operations, that is, would increase the cost $10 per acre of urban land per year.

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[18] *N. V. Colston, "Characterization and Treatment of Urban Land Runoff," U. S. Environmental Protection Agency, Publication No. 670/2-74-096, December 1974, pp. 65-87.*

[19] *G. Amy, et al, "Water Quality Management Planning for Urban Runoff," Environmental Protection Agency, Report No. 440/9-75-004, December 1974, pp. IV-6-IV-11.*

Because of the likelihood that improved efficiency in street cleaning procedures can be achieved at little additional cost, this estimating procedure is likely to produce conservatively high results. It was assumed that the added street sweeping cost was applied to all existing urban lands in the watershed, except for park and recreation lands, since they do not generally drain to the street and storm water drainage system. Application of the incremental costs of street cleaning operations to the 67 square miles of urban land meeting the above definition results in a total cost of $429,000 per year. Although a uniform, indiscriminate increase in the level of street sweeping is not necessarily recommended nor is it considered the only or complete solution of the diffuse source pollution problem in urban areas, the estimated average annual cost of such a more extensive street sweeping operation serves as an index of the cost of land management measures needed in urban areas for diffuse source pollution control.

Concluding Statement: Control of Washoff of Pollutants from the Land Surface

Based on the above analysis, it is recommended that pollution in rural areas caused by washoff from barnyards and feedlots be resolved by the construction of feedlot runoff pollution control systems consisting primarily of drainage control in and around each feedlot and provision of manure storage facilities. The total capital cost of this pollution abatement measure for the Menomonee River watershed is estimated at $400,000 and incremental operation and maintenance costs would be negligible. It is further recommended that runoff from agricultural lands be controlled primarily through application of basic land conservation measures such as contour plowing, strip cropping, and minimum tillage. The estimated total capital cost of implementing this recommendation is $230,000 with negligible incremental operation and maintenance costs. In the design phase of implementing this land management recommendation on individual farmsteads, consideration should be given to judicious use of bench terraces as soil, topographic, and crop conditions dictate. The above pollution abatement measures, in conjunction with the recommendation that existing unsewered urban areas and new urban areas be provided with sanitary sewer service, are intended to achieve the desired 50 percent reduction in land surface loading rates and in the concentration of potential pollutants in groundwater.

Many of the diffuse source pollution control measures available for application in urban areas can be implemented at little or no cost. It is recommended that communities in the Menomonee River watershed use a judicious blend of education and ordinance to encourage citizens to apply low or no-cost measures such as the following: control of littering by domestic animals; proper application of chemical and organic fertilizers and pesticides to lawns; control of litter and debris and proper material storage on private property and in public places; and control of sediment and debris during demolition and construction activities. It is further recommended that communities examine the manner in which municipal services such as street cleaning and maintenance, street de-icing, and garbage collection are performed to determine if the average amount of dust and dirt that accumulate on road surfaces can be significantly reduced with little or no increase in costs. It is also recommended that community officials encourage land developers to consider the use of detention-retention storage as a means of reducing the washoff of potential pollutants from the land surface to the surface waters—in addition to possibly reducing the cost of storm water control and achieving recreational and aesthetic benefits.

The estimated cost of a 50 percent increase in the effectiveness of street cleaning operations in the watershed is $429,000 per year. Although a uniform, indiscriminate increase in the intensity of street sweeping is not necessarily recommended and certainly is not the only solution to the urban diffuse source pollution problem, the estimated average annual cost of a more intensive street sweeping operation serves as an index of the cost of land management measures needed to achieve the desired level of diffuse source pollution control in urban areas.

In mid-1976, under the areawide water quality planning and management program, the Commission initiated a comprehensive review of the state-of-the-art of water pollution control measures. The final report, scheduled for publication in 1977, will include performance and cost information on diffuse source pollution control measures for rural and urban areas. This information, particularly that for urban areas should be useful to watershed communities in selecting, on a block-by-block basis, suitable measures for diffuse source pollution control.

THE SIGNIFICANCE OF FLOW RELIEF DEVICES AND THE CONSEQUENCES OF THEIR REMOVAL

As stated above, the water quality management plan element of the Menomomee River watershed plan assumes that between now and the year 2000 discharge of raw sanitary sewage from sewerage system flow relief devices—crossovers, bypasses, relief pumping stations, and portable pumping stations—will gradually be eliminated. An analysis of the relative pollutant loads from flow relief devices as opposed to other point and non-point sources was conducted to determine the likely significance of flow relief devices as pollution sources relative to sources such as sewage treatment plant discharges, washoff from the land surface, and groundwater discharge and to determine the likely consequences of eliminating or substantially reducing the pollution contribution from flow relief devices.

The effect of flow relief devices is not readily accommodated in the water quality submodel primarily because of insufficient detailed information concerning: the conditions under which such devices operate, the discharge rate during operation, and the concentration of various potential pollutants carried in the discharge. As described below, a comparison of pollution loads contributed by flow relief devices and pollution loads contributed by sewage treatment plants, washoff from the land surface, and groundwater flow, indicates that the flow relief devices constitute a small source and, therefore, omission of that pollution load from the modeling does not have a significant affect on the accuracy of simulated stream water quality.

Analysis Procedure

Inventory data presented in Chapter VII, Volume 1 of this report, indicate that flow relief devices are scattered about the watershed tributary to the Menomonee River, the Little Menomonee River, Underwood Creek, and Honey Creek and are located in the Cities of Milwaukee, Wauwatosa, West Allis, and Brookfield and the Village of Menomonee Falls.

Public officials in these communities were contacted by the Commission staff to obtain information as to the conditions—such as amount of precipitation—under which flow relief devices are likely to operate; the discharge rates likely to occur during such operation; and the concentration of potential pollutants likely to be present in the resulting combination of sanitary sewage and storm water that is discharged directly or indirectly to the surface waters of the basin. Although very little field data exist on the operation of flow relief devices, sufficient information was obtained from community officials to estimate the volume of water likely to enter the surface water system of the watershed via the flow relief devices in each community during a major storm event like that which occurred on April 20 and 21, 1973, during which almost four inches of rainfall occurred on the watershed, or that of September 17 to 21, 1972, during which almost four inches of rainfall also fell on the watershed. Based on descriptions of the quality of the flow discharged by the flow relief devices—descriptions that generally characterized flows as being similar to diluted sanitary sewage—the ultimate carbonaceous biochemical oxygen demand of flow relief device discharge was assumed to be 30 mg/l and the total phosphorus concentration in the discharge was set at 1 mg/l.

The estimated flow relief device discharge quantities during major precipitation events in combination with the assumed concentration of selected potential pollutants were used to determine the total mass discharge of pollutants from the above five communities into the surface waters system and these were in turn aggregated at the following five points in the watershed stream system: the Menomonee River immediately above its confluence with Little Menomonee River, the Menomonee River at Hawley Road, the Little Menomonee River at the Menomonee River, Underwood Creek at the Menomonee River, and Honey Creek at the Menomonee River. The resulting transports of potential pollutants originating at flow relief devices for the major precipitation events at these five locations are set forth in Table 41. The per event pollution transport values presented in the table and obtained using the above procedure represent only the discharge of pollutants to the stream system from flow relief devices.

The water quality submodel was then used to calculate the transport of ultimate carbonaceous biochemical oxygen demand and phosphate-phosphorus at the above five locations in the watershed for two major historic precipitation events in the Menomonee River watershed—that which occurred on April 20-21, 1973, and that which occurred on September 17-21, 1972. These events were drawn from the 10 year period from 1965 to 1974 and are events during which field surveys revealed the occurrence of basement flooding due to sanitary sewer backup and the resulting need to operate flow relief devices. The resulting transport of carbonaceous biochemical oxygen demand and phosphate-phosphorus as obtained from the Water Quality Submodel for each of the five selected locations on the watershed stream system are also set forth in Table 41. The per event pollution transport values presented in the table and as obtained using the model represent the discharge of pollutants to the watershed stream system from the four municipal sewage treatment plants, from the watershed land surface, and from groundwater discharge.

Results

Table 41 permits a comparison between the per event transport of selected pollutants input to the stream system from flow relief devices as opposed to the pollutants input from the municipal sewage treatment plants, the watershed land surface, and groundwater discharge during the same event. The table indicates that for the five locations, consisting of the two on the Menomonee River and one each on the Little Menomonee River, Underwood Creek, and Honey Creek and for both selected runoff events, the pollution load contributed by flow relief devices is small compared to the pollution load contributed by the combination of municipal sewage treatment plants, the watershed land surface, and groundwater discharge. More specifically, considering all five locations and both events, the CBOD load contributed by flow relief devices varies from 0.08 to 21 percent of the CBOD load contributed by the other major sources with a median value of 16 percent while the phosphorus load contributed by flow relief devices varies from 0.07 to 12 percent of the phosphorus load contributed by other major sources with a median value of 6 percent. Therefore, it was determined that the potential pollutant contribution of flow relief devices to the Menomonee River, the Little Menomonee River, Underwood Creek, and Honey Creek is not likely to significantly affect stream water quality and therefore need not be explicitly included in the modeling of surface water quality conditions.

Concluding Statement:
Significance of Flow Relief Devices

It is important to note that, although the above analysis indicates that modeling does not and need not include the pollutant load passing through flow relief devices, the modeling does include the quantity of water that passes through those devices. That water is largely storm water that is diverted through portions of the sanitary sewer system before reaching the stream system and is, therefore, reflected in the records of the stream flow gaging stations used to calculate the hydrologic-hydraulic portions of the model.

While the above analyses indicate that the flow relief devices contribute small quantities of pollution to the surface water of the Menomonee River watershed relative

Table 41

COMPARISON OF POLLUTANT LOADS CONTRIBUTED BY FLOW RELIEF DEVICES TO POLLUTANT LOADS CONTRIBUTED BY SEWAGE TREATMENT PLANTS, LAND SURFACE RUNOFF, AND GROUNDWATER FLOW

April 20-21, 1973 Runoff Event

Location			Precipitation at Nearest Meteorological Station (inches)	Ultimate CBOD (Carbonaceous Biochemical Oxygen Demand) Transport (lb.)			Phosphate-Phosphorus Transport (lb.)		
Stream	River Mile	Description		Contributed by Flow Relief Devices[a] (1)	Contributed by STP, Surface, Runoff and Groundwater Flow (2)	Ratio of (1) and (2)	Contributed by Flow Relief Devices[a] (1)	Contributed by STP, Surface, Runoff and Groundwater Flow (2)	Ratio of (1) and (2)
Menomonee River	5.14	Hawley Road	3.97	7,200	41,000	0.18	250	4,600	0.05
Menomonee River	12.52	Upstream of Confluence with Little Menomonee River	4.13	2,600	12,500	0.21	90	1,200	0.08
Little Menomonee River	0.00	At Menomonee River	4.13	10	5,200	0.002	0.3	450	0.0007
Underwood Creek	0.00	At Menomonee River	4.13	2,000	10,500	0.19	70	1,100	0.06
Honey Creek	0.00	At Menomonee River	3.97	1,300	6,500	0.20	40	900	0.04

September 17-21, 1972 Runoff Event

Location			Precipitation at Nearest Meteorological Station (inches)	Ultimate CBOD (Carbonaceous Biochemical Oxygen Demand) Transport (lb.)			Phosphate-Phosphorus Transport (lb.)		
Stream	River Mile	Description		Contributed by Flow Relief Devices[a] (1)	Contributed by STP, Surface, Runoff and Groundwater Flow (2)	Ratio of (1) and (2)	Contributed by Flow Relief Devices[a] (1)	Contributed by STP, Surface, Runoff and Groundwater Flow (2)	Ratio of (1) and (2)
Menomonee River	5.14	Hawley Road	3.95	7,200	73,000	0.10	250	3,800	0.07
Menomonee River	12.52	Upstream of Confluence with Little Menomonee River	4.54	2,600	31,500	0.08	90	1,600	0.06
Little Menomonee River	0.00	At Menomonee River	4.54	10	13,000	0.0008	0.3	300	0.001
Underwood Creek	0.00	At Menomonee River	4.54	2,000	14,000	0.14	70	600	0.12
Honey Creek	0.00	At Menomonee River	3.95	1,300	7,300	0.18	40	700	0.06

[a]Based on estimated discharge volumes and an ultimate CBOD concentration of 30 mg/l and a phosphate-phosphorus concentration of 1.0 mg/l.

Source: SEWRPC and Cities of Milwaukee, Wauwatosa, West Allis, and Brookfield and Village of Menomonee Falls.

to those contributed by sewage treatment plant discharge, washoff from the land surface, and groundwater discharge, pollutant contributions from flow relief devices may constitute local health hazards and create objectionable aesthetic conditions. Therefore, efforts should be continued to eliminate the discharge of sanitary sewage through flow relief devices. Disease-carrying bacteria, viruses, and other organisms are likely to be concentrated in backwater pools or on the ground in the vicinity of flow relief devices during and immediately after precipitation events and these organisms and the diseases they carry could be contacted by unwary individuals, particularly children who may not understand the hazardous situation. Furthermore, health considerations aside, the appearance of and odors associated with feces and other human waste floating on the streams in an urban and urbanizing area constitute a highly objectionable condition from a strictly aesthetic perspective.

It is noteworthy that the identification of flow relief devices has important implications not only for the resolution of health hazard and aesthetic problems as discussed above but also for the resolution of sanitary sewer surcharge with attendant structure water damage, public health hazards, and operating problems at sewage treatment plants. The presence and frequent operation of flow relief devices is symptomatic of sanitary sewers being surcharged by excess sanitary sewage flows not anticipated in the design of the system; by clear water that enters the system during rainfall-snowmelt events as clear water inflow through flooded manhold covers and through downspouts, footing tile drains, and sump pump discharge lines connected directly to the sanitary sewer system; and as groundwater infiltration through cracked or broken joints, pipes, and manhole walls.

The presence of extensive amounts of sewage and/or clear water in the sanitary sewer system usually causes basement inundation when the sanitary sewers back up into basements and also causes hydraulic overloads at sewage treatment plants necessitating the bypass of untreated sewage and sometimes leading to damage to treatment units and pumping facilities. The first problem—a combination "flood" damage and health hazard problem—is of direct concern to individual property owners while the second is of concern to community officials charged with responsibility of operating sewage treatment facilities so as to provide adequate treatment while protecting costly equipment from damage.

Serious water pollution and public health problems are associated with the frequent operation of numerous sanitary sewerage system flow relief devices in the urban environment. Consequently, a reduction in the number and frequency of operation and, to the extent possible, the elimination of flow relief devices is desirable. It is important to note, however, that sound engineering practice requires the existence of a minimum number of flow relief devices at critical points in the sanitary sewerage system each of which is designed to operate as a "safety valve" only infrequently during true emergencies such as power outages at pumping or lift stations or at sewage treatment plants.

In summary, while flow relief devices may not always have a severe impact on instream water quality conditions relative to other pollution sources such as municipal sewage treatment plants and land surface runoff, the identification and elimination of all but a few selected ones at critical points in the system is important for the following reasons: they are likely to constitute health hazards in the immediate vicinity of the discharge point; they may be expected to cause objectionable aesthetic conditions in the receiving streams; and they are symptomatic of excessive clear water entry into the sanitary sewer system and, therefore, of basement flooding and attendant health hazards and of hydraulic overloads at sewage treatment facilities.

ACCESSORY WATER QUALITY MANAGEMENT CONSIDERATIONS

Maintenance of Water Quality Monitoring Work

As discussed in Chapter VII, Volume 1 of this report, a variety of surface water quality monitoring efforts has been or is being carried out within the Menomonee River watershed. These monitoring programs include, but are not limited to: 1) periodic basin surveys by the Wisconsin Department of Natural Resources, begun in 1951; 2) a Commission water quality study conducted during the 1964-1965 period; 3) a Commission continuing water quality monitoring program conducted from 1968 to the present; and 4) the International Joint Commission Menomonee River Pilot Watershed Study under which monitoring began in late 1974 and is scheduled for completion in late 1977. Under the Menomonee River Pilot Watershed study, which is the most extensive and sophisticated of any of the water quality monitoring programs that have been or are being conducted in the watershed, the Wisconsin Department of Natural Resources maintains automatic water quality sampling and monitoring equipment at 12 sites positioned along the watershed stream system with the water quality sampling and analysis apparatus being protectively housed within semipermanent structures.

A well planned and executed water quality monitoring program can perform two important functions for the water quality management plan element of the comprehensive plan for the Menomonee River watershed. First, water quality monitoring can perform a surveillance function in that periodic sampling and analysis of the stream system can detect undesirable levels of pollution and help to determine the probable source so as to facilitate corrective actions. Second, a water quality monitoring effort, using historic and existing data as a "benchmark," can be used to demonstrate and document the expected marked improvement in the quality of surface waters in the Menomonee River watershed as the recommended water quality management plan element is implemented.

An important work element being conducted under the Commission areawide water quality planning and management program is a detailed and systematic examination of the results of water quality monitoring efforts to date throughout the planning region, including the Menomonee River watershed. In addition to assessing the long term trends in stream water quality in the urbanizing Southeastern Wisconsin Region, the analysis of historic water quality monitoring data is expected to result in recommendations for changes in the sampling programs. These alterations may include revision to and expansion of the number of water quality indicators included in the monitoring, modifications in the frequency of sampling, adjustments in the location of sampling stations, and provision for more coincident stream flow measurements. The analysis of historic water quality monitoring information, including recommendations for changes in the existing water quality monitoring programs, will be published in a technical report scheduled for completion and publication in early 1977. It is, therefore, recommended that the recommendations of that study as they apply to the Menomonee River watershed be considered for incorporation into the water quality management plan element of the comprehensive plan for the watershed.

Possible Future Refinements Upon Completion of Other Studies

As discussed in Chapter I, Volume 1 of this report, two other studies—each of which began after the initiation of the Menomonee River watershed planning program—are being conducted wholly or partly within the Menomonee River watershed. These are the International Joint Commission Menomonee River Pilot Watershed Study, a research investigation scheduled for completion in 1978, and the Washington County Project, another research effort scheduled for completion in mid-1978. In addition, and as noted in this chapter, the Southeastern Wisconsin Regional Planning Commission, under Section 208 of the Federal Water Pollution Act, initiated in July 1975 an areawide water quality planning and management program directed in part at resolution of diffuse or nonpoint source pollution from rural and urban areas and scheduled for completion by January 1978.

A common aspect of the above two research studies and the one planning program is that all are heavily concerned with diffuse source pollution. Because of the existence of this intensive research and planning activity within the seven-county southeastern Wisconsin planning area, it is possible that data obtained or analyses conducted during the above three studies may necessitate refinements in, or amendments to, the water quality control recommendations of the Menomonee River watershed plan subsequent to its publication and adoption. For example, a voluminous amount of water quality and quantity data are being obtained at 12 monitoring locations in the Menomonee River watershed under the Menomone River Pilot Watershed Study. As of mid-1976, just prior to completion of the Menomonee River watershed planning program, the above monitoring data were being assembled in a computer processible form. Some of these data will be utilized under the areawide water quality planning and management program to improve the water quality modeling capability. The anticipated resulting changes in water quality modeling may require amendments to the water quality management plan element of the comprehensive plan for the Menomonee River watershed resulting directly or indirectly from findings in the above three studies. These amendments would be made under the guidance of the Menomonee River Watershed Committee.

SUMMARY

The purpose of this chapter is to describe the extent to which water quality management recommendations pertinent to the Menomonee River watershed but developed under other Commission planning programs may be expected to mitigate or eliminate surface and ground water pollution problems that exist in the watershed and to present alternative water quality control measures intended to resolve watershed water quality problems not addressed in other Commission studies.

In an urban and urbanizing setting like the Menomonee River watershed, man's activities affect, and are affected by, the quality of surface and ground waters. A careful examination of the available water quality data for the Menomonee River watershed stream system for the period 1951 through 1974 indicates that the surface waters are severely polluted. Toxic, organic, nutrient, pathogenic, sediment, and aesthetic pollution are known to exist in the surface waters of the Menomonee River watershed. Groundwater pollution is evident in those portions of the watershed located primarily in the Cities of Brookfield and Mequon and the Villages of Menomonee Falls and Germantown, where about 14 percent of the watershed population use private wells in combination with onsite sewage disposal systems located on soils not well suited for use of such systems. As a result, problems have developed such as offensive odors and septic system discharge appearing in drainage swales in other low-lying areas. A more serious matter of concern is the threat to the public health as a result of direct contact with the septic tank system discharge, or as a result of the pollution of private groundwater supplies. The surface and ground water pollution problems of the Menomonee River watershed are attributable to the following pollution sources: municipal sewage treatment plants, sanitary and combined sewerage system flow relief devices, industrial discharge, urban storm water runoff, agricultural and other rural runoff, and onsite waste disposal systems.

Substantial efforts have already been initiated to resolve some of the pollution problems in the Menomonee River watershed. In accordance with recommendations contained within the adopted regional sanitary sewerage system plan for southeastern Wisconsin, the four municipal sewage treatment plants remaining in the watershed are scheduled to be permanently removed from service by about 1981 by connecting the sewer service area presently served by each of the four plants to the Milwaukee-Metropolitan sewerage system. The 27-square-mile Milwaukee Metropolitan combined sewer service area, which includes a 10.7-square-mile area tributary to the Menomonee River, is the subject of a preliminary engineering study directed at the abatement of combined sewer overflow. The study, which is scheduled for completion in late 1977, is to result in firm recommendations for construction of combined sewer overflow abatement facilities. The recently established Wisconsin Pollutant Discharge Elimination System is expected to result in a gradual abatement of pollution from sanitary sewerage system flow relief devices such as crossovers, bypasses, relief pumping stations, and portable pumping stations. The Wisconsin Pollutant Discharge Elimination System also is expected to gradually result in the abatement of pollution originating from industrial sources. Some remedial actions have been taken to resolve the creosote pollution problem in the bottom muds of the Little Menomonee River primarily by cessation of discharge to the Little Menomonee River and removal of creosote from the bottom muds of a 0.75-mile-long portion of the affected reach. The adopted regional sanitary sewerage system plan contains recommendations for the provision of sanitary sewer service to essentially all of those portions of the Cities of Brookfield and Mequon and the Villages of Menomonee Falls and Germantown presently served by septic systems. Implementation of these recommendations would eliminate the potential for pathogenic and aesthetic pollution from malfunctioning onsite disposal systems in the watershed. On July 1, 1975, the Southeastern Wisconsin Regional Planning Commission initiated an areawide water quality planning and management program directed in part at resolution throughout the Region of diffuse and non-point source pollution from rural and urban areas. This program is to provide a framework within which diffuse source pollution may be examined and resolved in the Region.

In consideration of the basic pollution abatement program already in progress within the Menomonee River watershed, the water quality management plan element for the watershed as developed under the watershed planning program was conducted within a framework of several overall and guiding assumptions. First, the planning program accepts as a committed decision the eventual abandonment of the four remaining municipal sewage treatment plants in the watershed; however, simulation studies were conducted to estimate the impact of removing the treatment plants. Second, the combined sewer overflow problem in the lower reaches of the watershed was not addressed because that problem includes the estuary, which is not within the scope of the watershed planning program and because planning and engineering studies are already underway by the Milwaukee-Metropolitan Sewerage Commission and its consultants to provide firm recommendations for that construction of combined sewer overflow pollution abatement facilities. Third, preparation of the water quality management plan element for the watershed plan does not include an explicit analysis of alternative ways of eliminating sanitary sewer system flow relief devices, since their removal will occur gradually under the Wisconsin Pollutant Discharge Elimination System, but does include an analysis of the relative pollutant loads from this source as opposed to other point and non-point sources. Fourth, and in a similar fashion, the water quality analyses assume that industrial discharges to the surface water system have a very small impact on water quality in the Menomonee River watershed relative to the impact of discharges from other point and non-point sources because of the nature of the discharges and their location in the watershed stream system and because these discharges will be controlled under the Wisconsin Pollutant Discharge Elimination System. Fifth, although the influx of creosote to the Little Menomonee River has been terminated, it was deemed necessary to examine alternative ways of removing the creosote that remains in the bottom muds because of the potentially detrimental impact of the creosote on inhabitants of the area as well as on flora and fauna. Sixth, it was assumed that localized pollution problems caused by the concurrent use of shallow, private wells, and onsite waste disposal systems will, between now and the plan year 2000, be resolved through implementation of recommendations in the adopted regional sanitary sewerage system plan which specifies that presently unsewered urban development as well as planned urban development should be provided with sanitary sewer service. Seventh, it was deemed necessary to examine possible adverse effects of washoff from the urban and rural land surfaces, including barnyards and feedlots, to the surface water system and to determine expected impact of planned incremental urban development as well as land management measures on the washoff process.

The Menomonee River watershed planning program included, in addition to the "no action" alternative, the development and examination of three alternative measures for abating the creosote problem that remains in portions of the Little Menomonee River within Milwaukee County. Under the first or "no action-no cost" alternative, a substantial hazard may be expected to continue to exist for a relatively long time along the affected 3.46 mile reach of the Little Menomonee River. The second alternative—the minimum disturbance approach—would employ the same procedure used during the 1973 EPA-sponsored demonstration project which was intended, in part, to resolve the creosote problem with a minimum disturbance of the Little Menomonee River and its environs. Alternative 2 could be accomplished for a capital cost of about $603,000. A third alternative, which would cost about $462,000, consists of removing creosote-laden bottom muds from the channel bottom followed by replacement with material intended to maintain a stable channel and to provide a medium for desirable aquatic flora and fauna. The fourth alternative, which has an estimated cost of $201,000, would entail excavating a new channel near and parallel to the affected reach of the Little Menomonee River with the excavated material being used to fill the existing channel, thereby covering the creosote that is contained therein. Based on a comparison of the technical, economic, and environmental aspects of the three alternatives, it is recommended that the creosote problem in the Little Menomonee River within Milwaukee County be resolved by excavating a new channel and filling the existing channel at a capital cost of about $201,000.

A series of water quality simulation model applications was made with the water quality submodel under existing and various possible future development conditions and water quality management measures in order to quantitatively demonstrate the likely consequences of those conditions and measures and thereby contribute to the development of a water quality management element. The simulation model studies indicate that removal of the four municipal sewage treatment plants under existing land use conditions and without any other water pollution abatement measures may be expected to yield the following water quality results along the main stem of the Menomonee River for the 7 day-10 year low flow conditions assumed in the analysis: no change in the already acceptable instream temperature, an improvement in dissolved oxygen concentrations so as to meet the standards, a substantial reduction in phosphorus levels but not sufficient to meet the standards, and a slight increase in fecal coliform counts so as to exceed the standards in the upper portion of the River. Assuming year 2000 planned land use conditions with abandonment of sewage treatment plants and with the implementation of land management measures, the water quality could be expected to improve so as to meet the temperature, dissolved oxygen, fecal coliform, and phosphate-phosphorus standards along most of the main stem of the Menomonee River under the specified 7 day-10 year low flow conditions.

Simulation model applications indicate a marked improvement in surface water quality in the Menomonee River watershed as determined by the percent of the time that the concentration of critical water quality parameters would be within recommended limits. Under a full range of meteorologic, runoff, and streamflow conditions, and assuming abandonment of the four remaining municipal sewage treatment plants and application of land management measures under year 2000 planned land use conditions, the temperature standard will be met about 95 percent of the time, the dissolved oxygen standard essentially all the time, and the coliform standard almost 90 percent of the time. The phosphorus standard could be expected to be met about half of the time since total phosphorus levels in natural, unpolluted headwater streams in southeastern Wisconsin approach or exceed the recommended maximum phosphate-phosphorus concentration without the impact of man's activities. Simulation model applications under year 2000 planned land use conditions with abandonment of the sewage treatment plants and application of land management measures indicate that the average annual transport of phosphate-phosphorus from the Menomonee River watershed by the Menomonee River may be expected to be reduced up to 90 percent relative to existing conditions whereas the average annual transport of carbonaceous biochemical oxygen demand will be reduced by up to 80 percent and total dissolved solids up to 50 percent.

The simulation model studies demonstrate that land management measures, in addition to abandonment of sewage treatment plants, are needed to affect a substantial improvement in surface water quality. It is recommended that pollution in rural areas caused by washoff from barnyards and feedlots be abated by the construction of feedlot runoff pollution control systems consisting primarily of drainage control in and around each feedlot and provision of manure storage facilities. The total capital cost of this pollution abatement measure for the Menomonee River watershed is estimated at $400,000 and incremental operation and maintenance costs would be negligible. It is further recommended that runoff from agricultural lands be controlled primarily through application of basic land conservation measures such as contour plowing, strip cropping and minimum tillage, supplemented with the judicious application of other measures including bench terraces. The estimated total capital cost of implementing this recommendation is $230,000 with negligible incremental operation and maintenance costs.

With respect to diffuse source pollution control in urban areas, it is recommended that communities in the Menomonee River watershed use a judicious blend of education and ordinance to encourage citizens to apply low or no-cost measures such as the following: control of littering by domestic animals; proper application of chemical and organic fertilizers and pesticides to lawns; control of litter and debris and proper material storage on private property and in public places; and control of sediment and debris during demolition and construction activities. It is also recommended that communities examine the manner in which municipal services such as street cleaning and maintenance, street de-icing, and garbage collection are performed to determine if the average amount of dust and dirt that accumulates on the road surfaces, and therefore is subject to washoff to the stream system, can be significantly reduced with little or no increase in costs. It is also recommended that community officials encourage land developers to consider the use of detention-retention storage as a means of reducing the washoff of potential pollutants from the land surface to the surface waters—in addition to possibly reducing the cost of stormwater control and achieving recreational and aesthetic benefits.

The estimated cost of a 50 percent increase in the effectiveness of street cleaning operations in the watershed is $429,000 per year. The estimated average annual cost of a more intensive street sweeping operation serves as an index of the cost of land management measures needed to achieve the desired level of diffuse source pollution control in urban areas.

An analysis of the relative pollutant loads from flow relief devices—crossovers, bypasses, relief pumping stations, and portable pumping stations—was conducted to determine the likely significance of the flow relief devices as pollution sources and the likely consequences of eliminating or substantially reducing the pollution contribution from flow relief devices. While flow relief devices may not always have so severe an impact on instream water quality conditions as other pollution sources such as municipal sewage treatment plants and land surface runoff, it is recommended that efforts be continued to eliminate discharge from such devices for the following reasons: they are likely to constitute a public health hazard in the immediate vicinity of the discharge point; they may be expected to cause highly objectionable aesthetic conditions in the receiving streams; and they are symptomatic of excessive clear water entry into the sanitary sewer system, and, therefore, of basement flooding and attendant health hazards and of hydraulic overloads at sewage treatment facilities.

It is recommended that recommendations to be developed under the areawide water quality planning and management program concerning a continuing surface water quality monitoring program in the Region, and to be published in early 1977, be considered by the Menomonee River Watershed Committee inasmuch as they apply to the Menomonee River watershed for incorporation into the water quality management plan element of the Menomonee River watershed plan. The following three research or planning studies—all of which emphasize diffuse source pollution—are underway in southeastern Wisconsin and scheduled for completion in 1978: the ICJ Menomonee River Pilot Watershed Study, the Washington County Project, and the areawide water quality planning and management program. It is possible that data obtained or analyses conducted during the above three studies may necessitate refinements in or amendments to the water quality management plan element of the watershed plan. It is recommended that such changes be made under the guidance of the Menomonee River Watershed Committee.

Chapter VI

RECOMMENDED COMPREHENSIVE PLAN

INTRODUCTION

The design of a comprehensive plan for the Menomonee River watershed required that a selection be made from among the several alternatives considered under each of the three major elements which together are to comprise the comprehensive watershed plan. These three major elements are: 1) a land use base element, including the natural resource protection, outdoor recreation and related open space, and parkway drive-scenic drive-recreational trail subelements of such an element; 2) a supporting floodland management element composed of various structural and nonstructural subelements; and 3) a supporting water quality management element composed of various point and diffuse source pollution abatement subelements.

The selection of the best alternative from among the various alternatives considered under each of these three major elements was based upon an evaluation of many tangible and intangible factors, with primary emphasis, however, upon the degree to which the various alternatives meet the established watershed development objectives and upon the accompanying costs. The final selection of the plan elements to be included in the comprehensive watershed plan must ultimately be made by elected public officials although engineers and planners may properly make recommendations based upon an evaluation of technical, economic, environmental, legal, financial, and administrative considerations.

The plan selection process, which involved the extensive use of advisory committees and both formal and informal public hearings, has been described in Chapter I of this volume. The alternative land use, floodland management, and water quality management plan elements considered have all been described in previous chapters of this volume. This chapter presents a description of the recommended comprehensive watershed development plan as synthesized from the best alternatives under each of the three major plan elements, along with a presentation of the basis for the synthesis and an analysis of the attendant costs. The chapter also contains an evaluation of the ability of the recommended plan to meet the adopted objectives and standards and discusses the likely consequences of not implementing the plan. Finally, the public reaction to the recommended plan and the subsequent action of the Menomonee River Watershed Committee are discussed.

BASIS FOR PLAN SYNTHESIS

The watershed development objectives which the comprehensive Menomonee River watershed plan is designed to meet are set forth in Chapter II of this volume. That chapter also sets forth the standards for relating these objectives to the physical development proposals which constitute the plan, thereby facilitating evaluation of the ability of each of the alternative plan proposals to meet the chosen objectives.

In each of the three chapters[1] in which the various alternative land use, floodland management and water quality management plan subelements have been set forth, the alternative proposals have been evaluated and recommendations made for inclusion of the best alternatives in the comprehensive watershed plan. In this process of plan selection, the various alternative plan subelements were evaluated, as appropriate, with respect to their technical, economic, environmental, legal, financial, and administrative feasibility as well as with respect to their ability to meet the appropriate watershed development objectives and supporting standards.

It is clear that no one land use or water control facility plan element can fully satisfy all of the watershed development objectives. The recommended comprehensive watershed plan must, therefore, consist of a combination of individual plan subelements, with each plan subelement contributing toward the satisfaction of the development objectives. It should be noted also in this respect that many of the alternative plan subelements were specifically designed to satisfy certain watershed development objectives and that, in this event, the selection from among the alternatives depends largely upon analysis of the attendant costs.

While the wise use of land is necessary to the environmental integrity of a watershed, the recommended land use base for the Menomonee River watershed will not, in and of itself, fully attain all of the watershed development objectives. This land use base element must, therefore, be supplemented by other plan elements relating to natural resource protection, outdoor recreation and related open space, parkway drive-scenic drive-recreational trails, floodland management, and water quality control. The various recommended plan alternatives, as set forth in Chapters III, IV, and V of this volume, are, in fact, complementary in nature and together provide the composition necessary to fully achieve all of the established watershed development objectives. The land use base and component natural resource protection plan subelements, for example, by providing a pattern of urban land use development which can be readily served by public sani-

[1] *Chapter III, Volume 2, "Land Use Base and Alternative Natural Resource Protection Measures"; Chapter IV, Volume 2, "Alternative Floodland Management Measures"; and Chapter V, Volume 2, "Alternative Water Quality Management Measures."*

tary sewerage and water supply facilities and by providing for the preservation of environmental corridor lands along the main stem of the Menomonee River and selected major tributaries, contribute toward achieving not only the land use development objectives but also the water quality and flood control objectives. Thus, the recommended comprehensive watershed plan represents a synthesis of carefully coordinated individual plan elements which, taken together, will serve fully to satisfy and achieve all of the adopted watershed development objectives.

Because of the extreme difficulty, if not impossibility, of expressing all of the benefits and costs associated with the comprehensive watershed plan in monetary terms, the evaluation of the recommended comprehensive plan has been based primarily on its ability to satisfy the watershed development objectives and supporting standards. The importance of economic analyses of certain of the individual plan subelements, however, as set forth in previous chapters of this volume, cannot be overemphasized, since these economic analyses comprise important inputs to the plan selection process, particularly so, as already noted, where alternative plan subelements were specifically designed to meet certain development objectives.

PLAN RECOMMENDATIONS

Based upon the analyses of the ability of the various plan elements to satisfy watershed development objectives and to exhibit acceptable benefit-cost features, as set forth in previous chapters of this volume, the specific plan elements set forth below are recommended for inclusion in the comprehensive plan for the Menomonee River watershed. Principal elements of the preliminary recommended comprehensive plan for the Menomonee River watershed are shown in graphic summary form on Map 50—the land use plan elements, Map 51—the floodland management plan element, and Map 52—the water quality management plan element.

Recommended Land Use Plan Element

Overall Land Use Plan: The controlled existing trend 1990 land use plan originally adopted by the Commission for the Region as a whole in 1966, and reevaluated and refined for the year 2000 by the Commission during the period 1972-1976, is recommended for adoption as the land use base element for the Menomonee River watershed (see Map 50). This land use plan element envisions use of a combination of public acquisition and public regulation of private holdings of land to shape the development of a land use pattern which will meet future needs for the various land uses within the watershed, including residential, agricultural, conservancy, and park uses, efficiently and with a minimal deteriorating effect upon the underlying and supporting natural resource base. This plan element places continued emphasis upon the urban land market as the primary determinant of the location, intensity, and character of future development within the watershed. It does, however, propose to regulate, in the public interest, the effect of this market on development in order to provide for a more orderly and economical land use pattern and in order to avoid intensification of the already serious developmental and environmental problems existing within the watershed.

Urban Development: Forecasts indicate that the population of the Menomonee River watershed may be expected to reach a level of about 388,000 persons by the year 2000, an increase of approximately 40,000 persons or 12 percent over the 1970 level, while employment may be expected to reach approximately 218,800 jobs by 2000, an increase of 48,200 jobs, or about 28 percent over the 1972 level. The recommended land use plan for the watershed proposes to accommodate this anticipated growth in population and employment through the conversion of approximately 15 square miles of land from rural to urban use over the next two to three decades.

As indicated in Table 6 of this volume, the recommended land use plan proposes to add about eight square miles of the existing stock of residential land within the watershed in order to meet the housing needs of the anticipated population increase. Nearly all new residential land would be developed at medium densities, with lot sizes ranging from about 6,000 square feet to about one-half acre per dwelling unit and with gross residential population densities ranging from 3,500 to 10,000 persons per square mile.

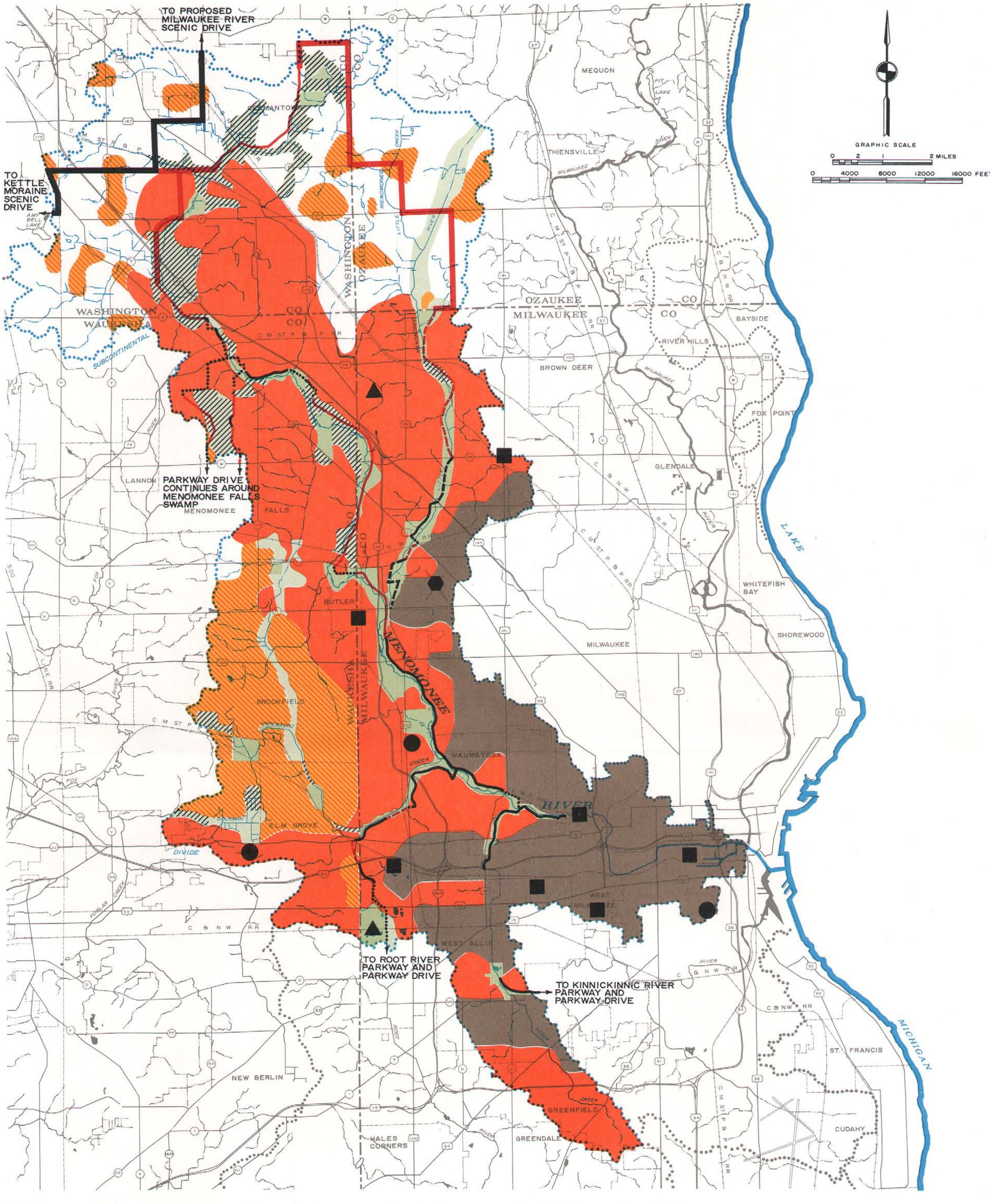
The recommended land use plan proposes that all of the new residential development be served by public sanitary sewerage and public water supply facilities so that, by the year 2000, essentially all of the urban area within the watershed and essentially all of the total watershed population would be served by public sanitary sewerage facilities, as compared to 84 and 89 percent, respectively, in 1970. Similarly, essentially all of the urban area and all of the total watershed population would be served by public water supply facilities by the year 2000, as compared to 77 percent and 85 percent, respectively, in 1970. As set forth in Chapter III of this volume, the plan contains similar proposals for the conversion of land to commercial, industrial, governmental and institutional, transportation, communication, and utility land uses as required to meet the gross demand for land generated by the anticipated population and employment within the watershed.

Agricultural Land Use: Under the recommended watershed land use plan, urban expansion within the watershed would by the year 2000 require the conversion of about 11 square miles of agricultural and related land, or about one-fourth of the approximately 45 square miles of land presently devoted to agricultural and agricultural-related uses within the watershed. The recommended land use plan proposes to preserve the remaining 34 square miles of agricultural land in permanent agricultural use.

Primary Environmental Corridor: As discussed earlier in this volume, the most important elements of the natural resource base of the watershed, including the best remaining woodlands, wetlands, and wildlife habitat; the surface waters, together with the associated undeveloped flood-

Map 50

PRELIMINARY RECOMMENDED LAND USE PLAN ELEMENT FOR THE MENOMONEE RIVER WATERSHED: 2000



LEGEND

- SUBURBAN RESIDENTIAL (0.2-0.6 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- LOW DENSITY URBAN (0.7-2.2 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MEDIUM DENSITY URBAN (2.3-6.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- HIGH DENSITY URBAN (7.0-17.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- AGRICULTURAL AND OPEN RURAL LAND

- MAJOR RETAIL AND SERVICE CENTER
- MAJOR INDUSTRIAL CENTER
- MAJOR AIRPORT
- MAJOR PUBLIC OUTDOOR RECREATION CENTER

PRIMARY ENVIRONMENTAL CORRIDOR

- EXISTING PUBLIC OR PRIVATE PARK AND RELATED OPEN SPACE LAND
- PROPOSED FOR PUBLIC AQUISITION
- PROPOSED TO BE PROTECTED THROUGH FLOODLAND AND CONSERVANCY ZONING

PARKWAY DRIVES-SCENIC DRIVES-RECREATIONAL TRAILS

- EXISTING PARKWAY DRIVE
- PROPOSED PARKWAY DRIVE
- EXISTING CONNECTING URBAN STREET
- EXISTING SCENIC DRIVE
- EXISTING CONNECTING RURAL ROADWAY TO BE DESIGNATED SCENIC DRIVE
- EXISTING RECREATIONAL TRAIL
- PROPOSED RECREATIONAL TRAIL

NOTE: SUBSEQUENT TO THE INFORMATIONAL MEETINGS AND PUBIC HEARING, THE RECOMMENDED LAND USE PLAN ELEMENT AS SHOWN ON THIS MAP WAS ALTERED SO AS TO: (1) CHANGE THE AGRICULTURAL AND OPEN RURAL LAND DESIGNATION IN SECTION 31 AND THE WESTERN ONE-FIFTH OF SECTION 32, T9N, R21E, CITY OF MEQUON TO LOW DENSITY URBAN USE; (2) REFLECT A COMMITTED DECISION BY THE CITY OF MEQUON TO EXPAND THE HUNTINGTON PARK SUBDIVISION IN SECTION 32, T9N, R21E; and (3) REVERT THE PRIMARY ENVIRONMENTAL CORRIDOR PROPOSED FOR PUBLIC ACQUISITION TO THE NATURAL STREAM CHANNEL ALONG UNDERWOOD CREEK DOWNSTREAM OF JUNEAU BOULEVARD IN THE VILLAGE OF ELM GROVE.

The land use plan element for the Menomonee River watershed is, as shown on this map, composed of three major subelements. The first subelement is a land use base under which new urban development would be encouraged to occur contiguously to and outward from existing urban development within the watershed, in planned neighborhood units. Under this land use base, new urban development would be provided with essential urban services, particularly centralized sanitary sewer and water supply services. No new urban development would be located in the natural floodlands, primary environmental corridors, or prime agricultural lands of the watershed. The second subelement of the land use plan element calls for the protection of 14.7 square miles of net primary environmental corridors in the watershed. This would be accomplished through maintenance of about 5.2 square miles of existing public and private outdoor recreation and open space lands in current or similar use; the public acquisition of about 6.3 square miles of selected high value primary environmental corridor lands located primarily along the main stem of the Menomonee River in Waukesha and Washington Counties; and the imposition of appropriate local land use controls to protect the remaining 3.2 square miles of primary environmental corridor from incompatible urban land uses. The third subelement of the land use plan element calls for the development of an interconnected system of about 56 miles of environmental corridor-oriented parkway pleasure drives, scenic pleasure drives, and recreational trails. The proposed drive-trail system would be comprised of about 16 miles of existing parkway pleasure drives, about 13 miles of new parkway pleasure drives, about 2 miles of existing recreational trails, about 5 miles of new recreational trails, about 13 miles of scenic pleasure drives routed over existing roads, and about 7 miles of interconnecting existing urban streets.

Source: SEWRPC.

lands and shorelands; and the best remaining potential park sites occur within the Menomonee River watershed in linear patterns termed primary environmental corridors. In Chapter III of this volume a corridor delineation procedure was described, which procedure utilized the Land Data Management System (Land DMS) developed by the Commission staff in conjunction with the Menomonee River Pilot Watershed Study being conducted by the International Joint Commission. Application of the Land DMS to the corridor delineation process resulted in the identification of primary environmental corridors in the Menomonee River watershed totaling about 16.3 square miles in area. These delineated corridors served as the basis for the design of alternative natural resource protection plan subelements, including minimum protection, intermediate protection, and maximum protection alternatives.

Upon completion of the design of the alternative natural resource protection plan subelements for the Menomonee River watershed, a comparison was made between the primary environmental corridors in the watershed as developed under the Menomonee River watershed study through application of the Land DMS with those primary environmental corridors developed by the Commission staff during preparation of the adopted regional land use plan for southeastern Wisconsin. As noted above, the total net primary environmental corridor area as delineated under the watershed study approximated 16.3 square miles. The total net primary environmental corridor delineated under the initial regional land use study approximated 14.7 square miles. The difference between the two figures may be attributed largely to suggested additional primary environmental corridor land along Willow Creek in the Villages of Germantown and Menomonee Falls. Other minor differences between the corridor delineations were due to differing judgements made as to the lateral extent of corridor lands along the stream channel system in the watershed.

Careful consideration of these differences indicated that they were not vital to attaining the overall objective of protecting and preserving the natural resource base of the watershed. In the interests of maintaining a uniform and common regional data base over time with respect to the primary environmental corridors, it was determined to utilize the initial primary environmental corridor delineation in the synthesis of the final recommended comprehensive plan for the Menomonee River watershed. Accordingly, the primary environmental data presented from this point on in this report refers directly to the data series developed under the Commission regional land use planning program.

Preservation of the primary environmental corridors in essentially natural open uses—and thereby the preservation of the attendant recreational, aesthetic, ecologic, and cultural values in accordance with regional and watershed development objectives—is essential to the maintenance of a wholesome environment within the watershed. It is recommended that the intermediate protection primary environmental corridor plan subelement, as initially presented in Chapter III of this volume as altered to reflect the initial primary environmental corridor data base, be incorporated into the comprehensive plan for the Menomonee River watershed. This plan subelement, through a combination of land acquisition and control seeks to protect the approximately 14.7 square miles of land and water comprising the net, or undeveloped, primary environmental corridors of the watershed. Under this plan subelement, a total of about 11.5 square miles, or about 78 percent of the net primary environmental corridor land within the watershed and about 8 percent of the total area watershed, would eventually be placed in public or private ownership for outdoor recreation and related open space uses. Of this total recreation and related open space acreage, about 5.2 square miles, or about 45 percent, is already in public or appropriate private ownership.

More specifically, the recommended primary environmental corridor protection plan subelement recommends:

- Continued maintenance of the 5.2 square miles of existing public and private outdoor recreation and open space land in such use;
- Public acquisition of 6.3 square miles of selected high value primary environmental corridor lands located primarily along the main stem of the Menomonee River in Waukesha and Washington Counties;
- Use of land use controls to protect the remaining 3.2 square miles of primary environmental corridor; and
- Application of sound woodland, wetland, and wildlife habitat management practices to all 14.7 square miles of net primary environmental corridor in the watershed.

The estimated costs of acquiring the 5.2 square miles of primary environmental corridor noted above are presented in a later section of this chapter. It should be noted that these costs were developed by applying the unit cost per acre factors set forth in Chapter III of this volume to the primary environmental corridor lands developed under the initial regional land use planning program.

It is important to recognize that the effectiveness of the recommended primary environmental corridor plan element is based in part on the assumption that privately owned lands currently used for recreation and related open space uses will continue to be used for such purposes. It is recommended that local communities help to assure such continued use by the careful application of recreational and conservancy zoning. While such zoning is not an absolute guarantee that the lands concerned will remain permanently in recreational and open space use, the application of such zoning will require formal action should a change in use be proposed by the private owners and provide an opportunity for public acquisition.

In addition to zoning and public acquisition in fee simple, other techniques may come into use during the watershed plan implementation period for maintaining privately owned land in uses compatible with primary environmental corridor preservation. Such techniques may include tax incentives to encourage the maintenance of land in agricultural, recreational, and other open space uses, to deed the purchase of scenic easements, and development rights.

As demonstrated in Chapter IX, Volume 1 of this report, with a few exceptions—motor boating, water skiing, target shooting—the existing recreational lands and facilities within the Menomonee River watershed should be adequate to satisfy the forecast year 2000 recreational demands. More specifically, and with respect to those outdoor recreation activities that require land ownership and intensive development, the near future needs of the watershed population would be satisfied with additional snow skiing lands, increased local swimming and golfing facilities. While these needs could be met by private development, they could also be met through use of the primary environmental corridor lands to be publicly acquired under the recommended primary environmental corridor protection plan subelement inasmuch as five of the 18 potential outdoor recreation sites in the watershed are included in that portion of the primary environmental corridor recommended for public acquisition.

Parkway Drives, Scenic Drives, and Recreational Trails: Pleasure driving constitutes the fifth most popular outdoor recreational activity in the Menomonee River watershed and, in addition, parkway and scenic drives and recreational trails provide a means whereby a large portion of the watershed population can gain access to and fully enjoy the remaining natural resources features and outdoor recreation and related open space areas of the watershed. Therefore, a parkway drive-scenic drive-recreational trails plan subelement is included as an integral part of the primary environmental corridor and outdoor recreation elements of the comprehensive watershed plan.

It is recommended that parkway drive-scenic drive-recreational trail plan subelement 3 be included in the comprehensive plan for the Menomonee River watershed. This plan subelement would provide an interconnected system of 56.8 miles of environmental corridor-oriented parkway pleasure drives, scenic pleasure drives, recreational trail, and interconnecting urban streets. The system would be composed of 16.0 miles of existing parkway pleasure drive, 13.2 miles of new parkway pleasure drives, 5.2 miles of new recreational trails, 2.3 miles of existing recreational trails, 13.2 miles of scenic pleasure drives routed over existing roads, and 6.9 miles of existing urban streets.

Recommended Floodland Management Plan Element

Critical Role of the Land Use Plan Element: The underlying floodland management plan element recommended for inclusion in the comprehensive Menomonee River watershed plan is nonstructural, consisting of the land use development proposals contained in the land use plan element of the watershed plan. The extent and placement of incremental urban development between now and the year 2000 are critical if intensification of the existing flood problems and the creation of new flood problems in the watershed are to be avoided since that aspect of the land use plan affects the hydrologic-hydraulic behavior of those portions of the watershed outside of the floodlands. The preservation of the primary environmental corridors is of utmost importance, since that aspect of the land use plan determines the hydrologic-hydraulic behavior of the watershed floodlands. Watershedwide hydrologic-hydraulic simulation studies clearly indicate that the severity of flood problems and associated monetary flood risks in the basin may be expected to be very sensitive to decisions concerning future land use development both within and outside of the watershed floodlands.

Primarily Structural Measures for Flood Damage Abatement: The recommended floodland management plan element for the Menomonee River watershed includes the application of primarily structural measures on a community-by-community basis for those riverine areas experiencing the most severe flood problems (see Map 51). Such measures are recommended for portions of the City of Brookfield, the Village of Elm Grove, the City of Wauwatosa, the Village of Menomonee Falls, the City of Mequon, and the City of Milwaukee.

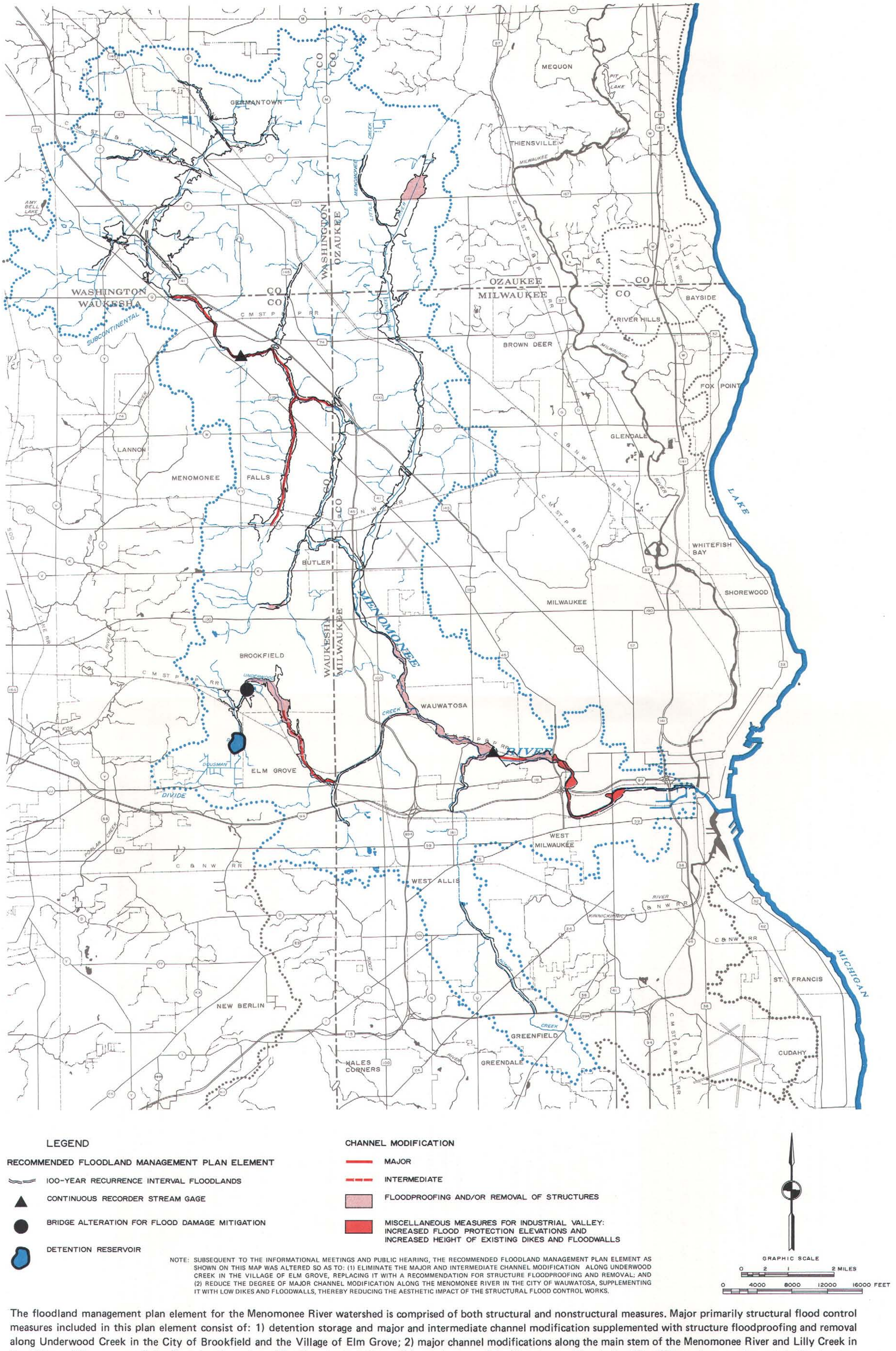
City of Brookfield: It isrecommended that the detention storage-bridge replacement-structure floodproofing and removal alternative be used to resolve existing and probable future flood problems along Underwood Creek in the City of Brookfield. This recommended alternative consists of the following three components: 1) a 215 acre-foot detention storage reservoir located upstream on Dousman Ditch in the City of Brookfield; 2) replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge over Underwood Creek; and 3) the floodproofing of up to 65 structures and the removal of approximately seven structures along the reach of Underwood Creek bounded at the upstream end of the railroad and at the downstream end by W. North Avenue.

It is recommended that structure floodproofing be used to resolve existing and probable future flood problems along the 1.26-mile-long reach of Butler Ditch upstream of Lisbon Road within the City of Brookfield. This recommended alternative would involve the floodproofing of up to 20 structures.

The Village of Elm Grove: It is recommended that the composite storage-major channelization-intermediate channelization-floodproofing alternative be used to resolve existing and probable future flood problems along Underwood Creek within the Village of Elm Grove. The recommended structural floodland management subelement for the Village of Elm Grove consists of the following four components: 1) a 215 acre-foot flood detention reservoir located upstream of the Village on Dousman Ditch in the City of Brookfield; 2) 0.91 miles of major channelization and necessary hydraulic structure

Map 51

PRELIMINARY RECOMMENDED FLOODLAND MANAGEMENT PLAN ELEMENT FOR THE MENOMONEE RIVER WATERSHED: 2000



The floodland management plan element for the Menomonee River watershed is comprised of both structural and nonstructural measures. Major primarily structural flood control measures included in this plan element consist of: 1) detention storage and major and intermediate channel modification supplemented with structure floodproofing and removal along Underwood Creek in the City of Brookfield and the Village of Elm Grove; 2) major channel modifications along the main stem of the Menomonee River and Lilly Creek in the Village of Menomonee Falls; 3) major channel modification along portions of the main stem of the Menomonee River in the City of Wauwatosa supplemented with structure floodproofing and removal; 4) structure floodproofing in the City of Mequon; and 5) structure floodproofing along the Menomonee River in the City of Milwaukee. Nonstructural floodland management measures included in this plan element consist of: regulation of land use development both inside and outside of the floodlands; participation in the federal flood insurance program; continuation of desirable lending institution and realtor policies concerning the sale of riverine area properties; supportive community utility policies; establishment of emergency flood warning programs; maintenance of a basic stream gaging network; and certain miscellaneous measures for mitigation of the residual flood problem in the Menomonee River industrial valley.

Source: SEWRPC.

replacement along the Underwood Creek reach bounded by the Waukesha-Milwaukee County line and Juneau Boulevard; 3) 1.14 miles of intermediate channel improvements—defined as a turf-lined channel, sized so as to convey the 10-year recurrence interval flood discharge under year 2000 plan conditions—and necessary hydraulic structure alteration along Underwood Creek between Juneau Boulevard and North Avenue; and 4) floodproofing of up to 105 residential structures located along the Underwood Creek reach bounded by Juneau Boulevard and W. North Avenue. The major channelization component of the recommended flood control alternative for the Village of Elm Grove would provide an opportunity to enhance the appearance of the business-commercial area by the development of an urban-oriented parkway along Underwood Creek.

The City of Wauwatosa: It is recommended that the channelization-structure floodproofing and removal alternative be used to resolve existing and probable future flood problems along the Menomonee River in the City of Wauwatosa between the eastern limits of the City and Harwood Avenue. The recommended primarily structural floodland management subelement for this reach of the Menomonee River consists of two components: 1) 1.22 miles of major channelization along the Menomonee River from a point about 0.25 miles downstream of Hawley Road to the N. 70th Street bridge, and 2) acquisition and removal of approximately 61 structures along the Menomonee River immediately upstream of the N. 70th Street bridge and floodproofing of up to 93 structures in that area. The structure floodproofing and removal component of this alternative would permit a 13 acre expansion of Hart Park—an intensively used recreational facility. Furthermore, this approach would permit retention of the natural features of the Menomonee River between N. 70th Street and Harwood Avenue and thus be consistent with proposals being considered by the City to revitalize the adjacent "Old Village area" and immediate environs.

It is recommended that structure floodproofing and removal be used to resolve existing and probable future flood problems along the Menomonee River between Harwood Avenue and W. Capitol Drive in the City of Wauwatosa. This recommended floodland management subelement would require the floodproofing of up to 211 structures and removal of approximately nine structures.

It is recommended that structure floodproofing be used to resolve existing and probable future flood problems in in the City of Wauwatosa along Honey Creek between the Menomonee River and W. Wisconsin Avenue. This recommended floodland management subelement would require the floodproofing of up to 13 structures.

It is recommended that structure floodproofing be used to resolve existing and probable future floodproblems in the City of Wauwatosa along Underwood Creek between the Menomonee River and the Zoo Freeway. This recommended floodland management subelement would require the floodproofing of up to 56 structures.

The City of Mequon: It is recommended that structure floodproofing be used to resolve existing and probable future flood problems along the Little Menomonee River in the City of Mequon immediately north of Mequon Road. This alternative would require the floodproofing of up to 19 structures.

The City of Milwaukee: It is recommended that structure floodproofing be used to resolve existing and probable future flood problems along the 0.93-mile-long reach of the Menomonee River in the City of Milwaukee between N. 45th Street and N. 60th Street Extended. This alternative would require the floodproofing of up to 77 structures.

The Village of Menomonee Falls: It is recommended that channelization be used to resolve existing and forecast flood problems along portions of the Menomonee River and Lilly Creek in the Village of Menomonee Falls. The recommended structural floodland management subelement for the Village of Menomonee Falls consists of the following three components: 1) 1.35 miles of major channelization along the Menomonee River from the Washington-Waukesha County line downstream to Menomonee Falls Dam, to 2) 3.25 miles of major channelization along the Menomonee River from Arthur Avenue downstream to the Waukesha-Milwaukee County line, and 3) 2.97 miles of major channelization along Lilly Creek from Silver Spring Drive downstream to the Menomonee River.

Bridge Replacement: It is recommended that bridges and culverts on the major stream system of the Menomonee River watershed which have inadequate hydrologic-hydraulic capacity as manifested by overtopping of the approach roads or of the structure be eventually modified or replaced so as to eliminate their interference with the desirable operation of the highway and railroad transportation system. Such replacement or modification, however, should be carried out only when required for traffic safety or other transportation purposes. The design of all new bridges within the watershed should be based upon the applicable objectives and standards set forth in Chapter II of this volume. Of particular importance is the standard which requires that all new and replacement bridges and culverts be designed so as to accommodate the 100-year recurrence interval flood event under year 2000 plan conditions without raising the peak stage more than 0.5 foot above the peak stage for the 100-year recurrence interval flood, as established in the adopted comprehensive watershed plan.

Land Use Controls: Recommended land use controls include both floodland and nonfloodland regulations.

Floodland Regulations: It is recommended that the following communities modify existing floodland and related regulations or prepare new floodland regulations based upon the new flood hazard data and the floodland management concepts and recommendations set forth in this report: the Cities of Brookfield, Mequon, Milwaukee, Wauwatosa, West Allis, and Greenfield and the Villages of Elm Grove, Germantown, Menomonee Falls, and Butler. In addition to meeting minimum hydrologic-hydraulic standards established by the State of Wisconsin Floodplain Management Program, it is recommended that the floodland and related regulations developed by the above communities for the Menomonee River watershed be explicitly designed to complement the recommended land use plan element. This is particularly important for the primary environmental corridor subelement of that plan which recommends protection of 14.7 square miles of net primary environmental corridor by a combination of four measures: maintenance of 5.2 square miles of existing public and private outdoor recreation and related open space lands; acquisition of 6.3 square miles of selected high value primary environmental corridors; application of woodland-wetland and wildlife habitat management techniques to all corridor lands; and the use of land use controls, particularly floodland and related regulations, to protect those 3.2 square miles of primary environmental corridor lands not in public or private outdoor recreation use and not recommended for acquisition under the watershed plan. It is also recommended that floodland and related regulations be employed to provide interim control over corridor lands recommended for eventual acquisition.

It is recommended that one of two basic types of floodland and floodland related measures be instituted by local units of government on a reach-by-reach basis in the watershed. These two measures are:

1. In those areas of the floodlands lying within the 100-year recurrence interval flood hazard lines under year 2000 plan conditions, that are presently neither developed for urban use nor committed to such development by the recordation of land subdivision plats and installation of municipal improvements such as street pavements and sewer and water utility lines, all future incompatible urban development be discouraged through appropriate floodland and floodland-related land use regulations. These stringent regulations would be applicable to about 56 miles of the 72 miles of watershed stream system for which the preparation and adoption of floodland regulations are recommended in the watershed plan.

2. In those areas of floodland that are already completely or partly developed for urban uses, or committed to such development, the floodland and floodland-related land use regulations should be designed so as to accommodate existing development, to preserve sufficient conveyance capacity for the 100-year flood flow through delineation and preservation and open use of a floodway, and to require the floodproofing of all new urban development committed in the floodplain fringe. This type of floodland regulation, which recognizes existing commitment to urban development, would be applicable to about 16 miles of the approximately 72 miles of watershed stream system for which the preparation and adoption of floodland regulations are recommended in the watershed plan.

Control of Land Use Outside of the Floodlands: Because of the demonstrated hydrologic-hydraulic impact of land use outside the floodlands on the extent and severity of flood problems within the floodlands, it is recommended that land use controls outside the floodlands, particularly as needed to achieve the year 2000 land use plan, be viewed as an important floodland management measure for the Menomonee River watershed. Such land use controls may take the form of or be incorporated into zoning, land subdivision, sanitary and building ordinances adopted by counties, cities, villages, and towns under police powers granted by the State Legislature.

Flood Insurance: Significant steps have been taken by watershed communities towards participation in the Federal Flood Insurance Program in that all the seven cities and six villages located wholly or partly in the Menomonee River watershed, as well as the unincorporated areas of the watershed, have taken the necessary affirmative steps to be eligible to participate in the insurance program. Furthermore, the U. S. Department of Housing and Urban Development has authorized insurance rate studies for the Cities of Greenfield, Milwaukee, Wauwatosa, New Berlin, and Brookfield and for the Villages of Menomonee Falls and Butler. It is recommended that the U. S. Department of Housing and Urban Development, in cooperation with the Wisconsin Department of Natural Resources, authorize the conduct of insurance rate studies in the Cities of West Allis and Mequon and the Villages of Germantown and Elm Grove. It is further recommended that contractors retained by the U. S. Department of Housing and Urban Development to conduct the flood insurance rate studies base those studies on the flood hazard data developed under the watershed program. Finally, it is recommended that owners of property in flood-prone areas purchase flood insurance to provide some financial relief for losses sustained in future floods.

Lending Institution and Realtor Policies: It is recommended that lending institutions continue to determine the flood-prone status of properties prior to granting of a mortgage and that the principal source of flood hazard information be that developed under the watershed planning program. It is also recommended that real estate brokers, salesmen, and their agents continue to inform potential purchasers of property of any flood hazard which may exist at the site in accordance with the 1973 executive order by the Governor of Wisconsin.

Community Utility Policies and Emergency Programs: It is recommended that the policies of governmental units and agencies having responsibility for public utilities and facilities, such as water supply, sewerage, and streets and highways within the watershed be designed to complement the land use and floodland regulations recommendations for the Menomonee River watershed and the recommended primary environmental corridor protection plan subelement. Although the hydrologically "flashy" and unpredictable nature of Menomonee River watershed flooding renders a flood forecasting system impractical, it is recommended that each watershed community develop procedures to provide floodland residents and other property owners with information about floods already in progress. The flood information procedures for a particular community might be selected from the following: monitoring of National Weather Service broadcasts during periods when rainfall or snowmelt are occurring or anticipated, patrolling riverine areas to detect rising stages and bankfull conditions, emergency messages broadcast over local radio and television stations, use of police patrol cars or other vehicles equipped with public address systems, and use of warning sirens particularly during night-time hours.

Maintenance of Stream Gaging Network: Continuous recording stream gaging stations, partial record stations, and crest stations located throughout the Menomonee River watershed can provide critical data essential to the future rational management of the surface water resources of the basin. It is recommended that the two continuous recorder gages temporarily installed at the N. 70th Street crossing of the Menomonee River in Wauwatosa and on the Menomonee River at Pilgrim Road (CTH YY) in the Village of Menomonee Falls for purposes of the IJC Menomonee River Pilot Watershed Study continue to be operated subsequent to completion of that research project. It is recommended that two of the three partial record stations operated in the basin by the U. S. Geological Survey in cooperation with the Wisconsin Departments of Transportation and Natural Resources—the Freistadt gage on the Little Menomonee River and the Milwaukee gage on Honey Creek—be operated through 1980, and that the third gage—the Menomonee Falls gage at the Washington-Waukesha County line—be abandoned since it would be replaced by the recommended continuous stage recorder on the Menomonee River at Pilgrim Road in Menomonee Falls. It is recommended that the Village of Menomonee Falls, the City of Milwaukee, and the Milwaukee-Metropolitan Sewerage Commissions continue to maintain their crest stage or staff gage networks; and it is also recommended that the Cities of Mequon and Brookfield and the Villages of Germantown and Elm Grove establish and maintain a network of crest stage or staff gages to provide for the acquisition of high water data during future flood events.

The existence in the watershed of 12 semipermanent structures located throughout the basin and containing sophisticated stream flow and water quality monitoring devices offer a unique opportunity for continued hydrologic, hydraulic, and water quality research in southeastern Wisconsin. It is recommended, therefore, that research institutions having responsibilities in water resource and water resource-related areas in the watershed give consideration to the development of research projects, educational programs, and other special studies that could incorporate portions of existing and extensive water quality-quantity monitoring networks within the watershed.

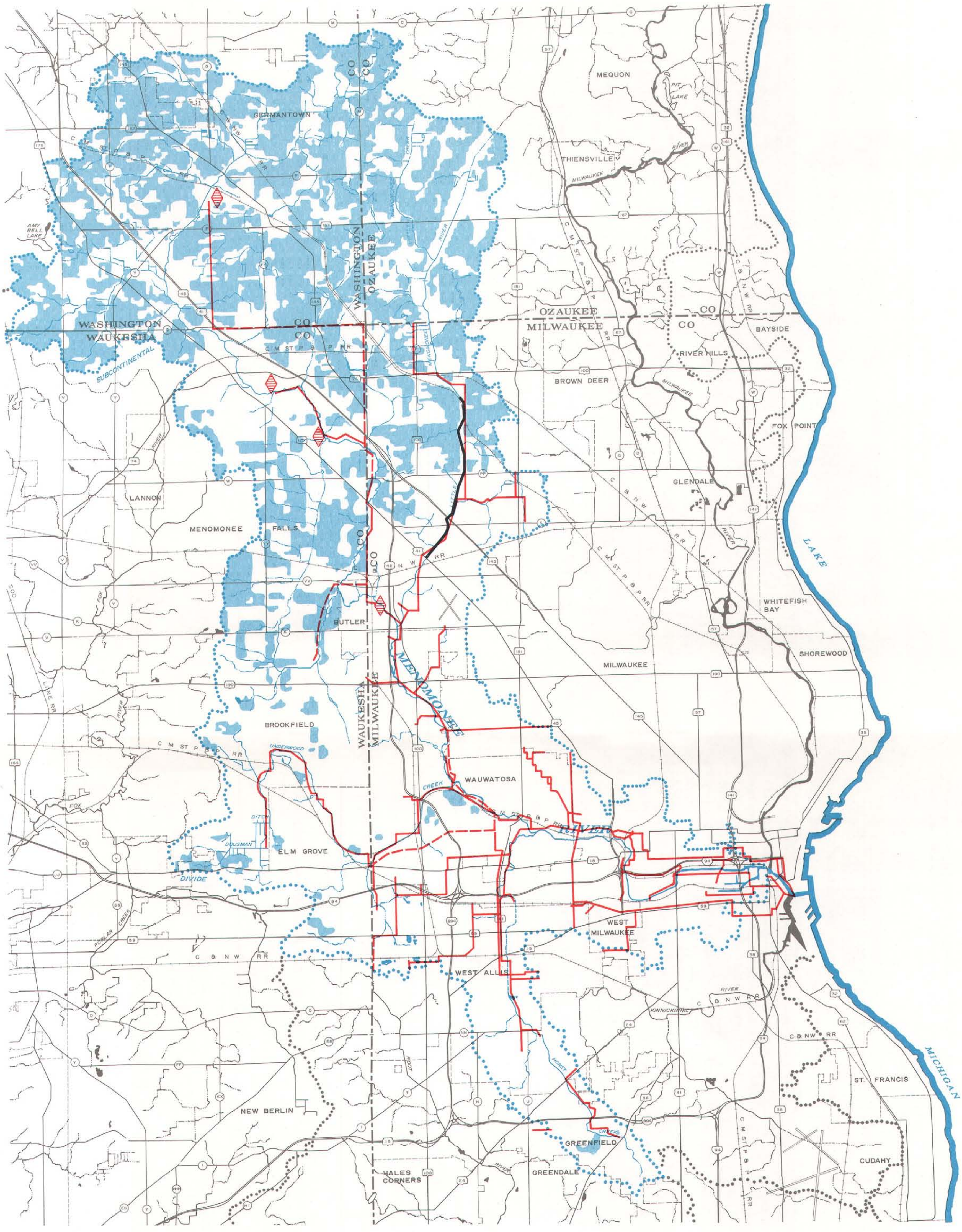
Miscellaneous Measures for the Menomonee River Industrial Valley: It is recommended that a new flood protection elevation of at least two feet above the 100-year recurrence interval peak flood stage profile for year 2000 land use plan conditions be established along the Menomonee River in the industrial valley upstream of River Mile 1.75 superseding the flood protection elevation presently established for that reach by the Sewerage Commissions. Consideration should be given to removal of The Falk Corporation dam in order to reduce flood stages at the earthen dike protecting the south boundary of the Chicago, Milwaukee, St. Paul, and Pacific Railroad yard and, in the event that The Falk Corporation dam is required to be retained, the crest of the dike protecting the railroad yard should be raised. In order to protect the residential area lying east of the Menomonee River between IH 94 and the W. Wisconsin Avenue viaduct from flooding under probable future flow conditions, a floodwall should be constructed along the east bank of the River in this reach, and necessary backwater gate and storm water pumping stations should be installed near the end of the storm sewer outfalls. Similar floodwall extensions and backwater gates should be installed along the west bank of the 0.16-mile-long reach of the Menomonee River between W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad and along all or portions of both sides of the Menomonee River channel between the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and the N. 45th Street crossing of the River.

Recommended Water Quality Management Plan Element
Abandonment of Municipal Sewage Treatment Plants: The recommended water quality management plan element for the Menomonee River watershed incorporates the recommendations contained in the adopted regional sanitary sewerage system plan for southeastern Wisconsin to abandon the four municipal sewage treatment plants in the watershed. These four treatment plants, all of which discharge to the main stem of the Menomonee River, are: the Village of Germantown Old Village plant, the Village of Menomonee Falls Pilgrim Road and Lilly Road plants, and the Village of Butler overflow-chlorination facility. Achievement of this recommendation is contingent in part on completion of remaining segments of the recommended intercommunity trunk sewer system as shown on Map 52.

Abatement of Combined Sewer Overflows: A preliminary engineering study currently underway and scheduled for completion in 1977 will provide recommendations for abatement of combined sewer overflows from the 10.7-square-mile combined sewer service area in the lower reaches of the Menomonee River watershed. That study,

Map 52

PRELIMINARY RECOMMENDED WATER QUALITY MANAGEMENT PLAN ELEMENT FOR THE MENOMONEE RIVER WATERSHED: 2000



LEGEND

PUBLIC SEWAGE TREATMENT PLANT TO BE ABANDONED

EXISTING OR PROGRAMMED MAJOR TRUNK SEWER OR FORCE MAIN

PROPOSED MAJOR TRUNK SEWER OR FORCE MAIN

NEW CHANNEL TO SOLVE CREOSOTE PROBLEM

AGRICULTURAL AND RELATED LAND HAVING A SLOPE EQUAL TO OR GREATER THAN TWO PERCENT AND LIKELY TO REQUIRE LAND MANAGEMENT

NOTE: THE FOLLOWING WATER QUALITY MANAGEMENT RECOMMENDATIONS ARE NOT SHOWN ON THIS MAP:

1. FACILITIES NEEDED TO ABATE COMBINED SEWER OVERFLOW POLLUTION FROM THE 10.7 SQUARE MILE COMBINED SEWER SERVICE AREA IN THE LOWER PORTION OF THE WATERSHED
2. ELIMINATION OF SEWAGE FLOW RELIEF DEVICES—CROSSOVERS, BYPASSES, AND RELIEF PUMPING STATIONS—AND INDUSTRIAL DISCHARGES
3. PROVISION OF SANITARY SEWER SERVICE TO APPROXIMATELY 12 SQUARE MILES OF PRESENTLY UNSEWERED URBAN LANDS AND TO ALL—ABOUT 15 SQUARE MILES—PLANNED URBAN DEVELOPMENT
4. INSTALLATIONS OF SYSTEMS FOR THE CONTROL OF POLLUTED RUNOFF FROM 40 BARNYARDS AND FEEDLOTS
5. MEASURES TO REDUCE POLLUTED RUNOFF IN URBAN AREAS

GRAPHIC SCALE

0 ½ 1 2 MILES

0 4000 8000 12000 16000 FEET

The water quality management element of the Menomonee River watershed plan incorporates those water quality management measures recommended in other adopted SEWRPC plans which are directly applicable to the watershed including: abandonment of the four remaining municipal sewage treatment plants; abatement of the combined sewer overflows; elimination of separate sanitary sewer flow relief devices; and provision of sanitary sewer service to existing and planned urban development. In addition, the water quality management plan element calls for control of industrial discharges and elimination of the residual creosote pollution problem in the Little Menomonee River. Land management measures would be invoked to reduce the surface water pollution associated with washoff of pollutants from rural and urban land surfaces, including animal feedlots.

Source: SEWRPC.

being conducted by the Milwaukee-Metropolitan Sewerage Commissions, grew out of recommendations contained in the adopted Milwaukee River watershed plan of the Regional Planning Commission. Insofar as the recommendations forthcoming from that preliminary engineering study are consistent with the water use objectives and standards established under the Menomonee River watershed planning program, it is proposed that the findings and recommendations of that preliminary engineering study be considered as an integral part of the comprehensive watershed plan; and that more specifically, the construction of the necessary transmission, storage, and treatment facilities needed to abate the combined sewer overflow problem in the Menomonee River watershed as well as in the neighboring Milwaukee and Kinnickinnic River watersheds be implemented as soon as practicable.

Elimination of Flow Relief Devices: The recommended water quality management plan element for the Menomonee River watershed incorporates the recommendation contained in the adopted regional sanitary sewerage system plan for southeastern Wisconsin that the 102 flow relief devices—crossovers, bypasses, and relief pumping stations—discharging directly or indirectly to the Menomonee River and tributaries during wet weather be gradually eliminated through trunk and relief sewer construction. Furthermore, it is recognized that the recently instituted Wisconsin Pollutant Discharge Elimination System which requires a permit and a pollution abatement schedule for each device, provides an effective mechanism for gradual elimination of the flow relief devices in the Menomonee River watershed.

Elimination of Industrial Discharges: The recommended water quality management plan element of the Menomonee River watershed plan proposes that the direct or indirect discharge of industrial wastes to the Menomonee River and its tributaries from 44 industrial discharge points be abated or eliminated. It is recognized that such abatement or elimination can be achieved under the recently inaugurated Wisconsin Pollutant Discharge Elimination System which requires a permit and pollution abatement schedule for each industrial discharge device.

Abatement of Creosote Pollution: It is recommended that the residual creosote pollution problem in the Little Menomonee River within Milwaukee County be resolved by excavating a new parallel channel, filling the existing channel, and restoring the site. The recommended pollution abatement measure would be applied along a 3.46-mile-long reach of the Little Menomonee River and would result in a significant reduction in creosote exposure and attendant hazard to people and aquatic flora and fauna.

Provision of Sanitary Sewer Service: The water quality management plan element of the watershed plan incorporates the recommendation contained in the adopted regional sanitary sewerage system plan for southeastern Wisconsin that sanitary sewer service be provided to presently unsewered urban areas within the watershed and to all planned new urban development. This recommendation requires the provision of sanitary sewer service to approximately 12 square miles of presently unsewered urban development within the basin and to approximately 15 square miles of urban development anticipated between now and the year 2000 in accordance with the land use plan element for the watershed.

Application of Land Management Measures: Water quality analyses conducted under the watershed planning program indicate that a significant reduction in washoff of pollutants from the land surface would, in combination with other pollution abatement measures, result in a marked improvement in surface water quality.

It is recommended that pollution in rural areas caused by runoff from agricultural land be controlled primarily through the application of basic land conservation measures such as contour plowing, strip cropping, and minimum tillage supplemented with the judicious application of other measures including bench terraces. It is further recommended that pollution caused by washoff from barnyards and feedlots be abated by the construction of feedlot runoff pollution control systems consisting primarily of drainage control around each feedlot and provision of manure storage facilities.

With respect to diffuse source pollution control in urban areas, it is recommended that communities in the Menomonee River watershed use a judicious blend of education and ordinance to encourage citizens to apply low or no-cost measures such as the following: control of littering by domestic animals, proper application of chemical and organic fertilizers and pesticides to lawns, control of litter and debris and proper material storage on private property and in public places, and control of sediment and debris during demolition and construction activities. It is also recommended that communities examine the manner in which municipal services such as street cleaning and maintenance, street de-icing, and garbage collection are performed to determine if the average amount of dust and dirt that accumulates on road surfaces, and therefore is subject to washoff to the stream system, can be significantly reduced with little or no increase in costs. It is also recommended that community officials encourage land developers to consider the use of detention-retention storage as a means of reducing the washoff of potential pollutants from the land surface to the surface waters—in addition to possibly reducing the cost of storm water control and achieving recreational and aesthetic benefits.

Maintenance of a Water Quality Monitoring Program: Water quality monitoring at selected stations located throughout the Menomonee River watershed can provide critical data essential to the future rational management of the surface water resources of the basin. It is recommended that proposals to be developed under the areawide water quality planning and management program, and published in early 1977, on a continuing surface water quality monitoring program in the Region be considered by the Menomonee River Watershed Committee insofar as they apply to the Menomonee River watershed for incorporation into the water quality management plan element of the watershed plan.

Possible Need for Plan Refinement: The following three research or planning studies—all of which emphasize diffuse source pollution—are underway in southeastern Wisconsin and scheduled for completion in 1978: The IJC Menomonee River Pilot Watershed Study, the Washington County Project, and the SEWRPC areawide water quality planning and management program. It is possible that data obtained or analyses conducted during the above three studies may necessitate refinements in or amendments to the water quality management plan element of the watershed plan. It is recommended that such changes be made under the guidance of the Menomonee River Watershed Committee.

COST ANALYSIS

In order to assist public officials in evaluating the foregoing recommended comprehensive Menomonee River watershed plan, a preliminary capital improvement program with attendant operation and maintenance costs was prepared which, if followed, would result in total watershed plan implementation by the year 2000. In addition, an analysis was made of recent public expenditures for park and open space lands and major channel modifications in order to determine if sufficient monies were likely to be available to implement the recommended watershed plan. Capital costs and operation and maintenance expenditures assigned to the Menomonee River watershed plan exclude the cost of pollution abatement measures recommended in the adopted regional sanitary sewerage system plan. These water quality management subelements, the cost of which is presented below, include: trunk sewer construction necessary to permit abandonment of the four remaining municipal sewage treatment plants in the watershed; abatement of pollution from sanitary sewer flow relief devices; and abatement of combined sewer overflows.

Plan Element Costs

The preliminary capital improvement program includes the staging of the necessary land acquisition and facility construction and the distribution of the attendant costs including operation and maintenance expenditures over a 24-year period. This expenditure program is presented in summary form for the watershed as a whole in Table 42. This table sets forth the land acquisition and construction costs and estimated operation and maintenance expenditures associated with implementation of each of the three recommended plan elements—land use, floodland management, and water quality—and associated subelements by year. The ultimate adoption of capital improvement programs for implementation of the watershed plan will require determination by the responsible public officials not only of those plan subelements which are to be implemented, and the timing of such implementation, but also of the principal beneficiaries and available means of financing.

The preliminary schedule of capital and operation and maintenance costs set forth in the referenced table is based on present (1975) costs for land acquisition, facility construction, and operation and maintenance. The use of present land acquisition, facility construction, and operation and maintenance costs in the schedule of future expenditures is sound since in the event that costs increase or decrease as a result of general price inflation or deflation the corresponding revenues available to units of government are likely to increase or decrease in an approximately proportional manner and thus the relative magnitude of scheduled costs and anticipated revenues is likely to be maintained. That is, if the schedule of capital and operation and maintenance cost, as set forth in Table 42, appears reasonable and achievable in the light of present costs and revenue situations, it is likely to be equally reasonable and obtainable under future changing cost and revenue situations.

Although the primary beneficiaries of implementation of the recommended comprehensive watershed plan will be the residents of the Menomonee River watershed, certain regional, state, interstate, and national benefits will accrue from full plan implementation. This fact should make many of the major plan recommendations eligible for financial assistance from the state and federal levels of government. The possible sources of state and federal financial assistance are described in Chapter VII of this volume. It is estimated that full utilization of these financial resources for watershed plan implementation could serve to reduce the local plan implementation costs by approximately 50 percent.

The full capital investment and operation and maintenance cost of implementing the recommended comprehensive plan for the Menomonee River watershed is estimated at $38.8 million over the 24-year plan implementation period. Of this total cost, about $10.6 million or about 27 percent, are required for implementation of the recommended land use plan element which includes the overall land use plan subelement, the primary environmental corridor protection subelement, and the parkway drive-scenic drive-recreational trail subelement. About $17.1 million, or about 44 percent, of the full cost associated with the watershed plan are required for implementation of the recommended floodland management element including recommended channel modifications, detention storage, structure floodproofing and removal, bridge modification, continued operation of a stream gaging network, and miscellaneous flood damage control measures in the industrial valley. About $11.1 million, or about 29 percent, of the full cost of implementing the recommended comprehensive watershed plan are required for implementation of those subelements of the recommended water quality management element not included in other adopted regional plan elements. These elements consist of the measures proposed to abate the residual creosote pollution problem in the Little Menomonee River, installation of feedlot runoff control systems, and application of land management measures to both rural and urban portions of the watershed for control of diffuse source pollution. Capital costs and operation and maintenance expenditures assigned to the water quality management element of the watershed plan exclude the cost of pollution abatement measures—such as trunk sewer construction to permit abandonment of municipal sewage treatment plants—recommended for the Menomonee River watershed under other adopted SEWRPC plans such as the comprehensive plan for the Milwaukee River watershed and the regional sanitary sewerage system plan.

The average annual cost of the total capital investment and operation and maintenance cost required for plan implementation would be approximately $1.62 million, or about $4.40 per capita per year over the 24-year plan implementation period, the per capita cost being based on a resident watershed population of 368,000 persons, equal to the anticipated average resident population of the watershed between the 1970 population level of 348,000 persons and the anticipated year 2000 population level of 388,000 persons. The average annual costs of implementation of the land use plan element, the floodland management plan element, and the water quality management plan element are, respectively, about: $440,300, or $1.20 per capita; $712,200, or $1.94 per capita; and $463,700, or $1.26 per capita.

Land Use Plan Element: Costs assignable to the land use plan element do not include the capital and operation and maintenance costs associated with implementation of the overall land use plan element since that recommended plan is contained within the adopted land use plan for southeastern Wisconsin and the attendant benefits and costs were considered during the preparation of that land use plan. It should be noted that Table 42 indicates that all of the land acquisition required for implementation of the primary environmental corridor subelement and all of the roadway construction needed for implementation of the parkway drive-scenic drive-recreational trail subelement would be carried out during the first 10 years of the 24-year plan implementation period. This accelerated land acquisition and parkway drive construction process is recommended in order to

Table 42

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE PRELIMINARY RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED BY PLAN ELEMENT AND BY YEAR: 1977-2000

Calendar Year	Project Year	Land Use Plan Element							
		Primary Environmental Corridor Subelement		Parkway Drive-Scenic Drive-Recreational Trail Subelement					
				Parkway Drive		Recreational Trail			
		Land Acquisition[a]	Operation and Maintenance[b]	Construction[c]	Operation and Maintenance[d]	Construction[e]	Operation and Maintenance[f]	Scenic Drive and Interconnecting Urban Street[g]—Signing and Marking	Subtotal
1977	1	$ 397,860	$ 20,020	$ 212,000	$ 1,580	$ 19,200	$ 310	$ 330	$ 651,300
1978	2	397,860	40,040	212,000	3,160	19,200	630	270	673,160
1979	3	397,860	60,050	212,000	4,760	19,200	930	240	695,040
1980	4	397,860	80,080	212,000	6,340	19,200	1,250	210	716,940
1981	5	397,860	100,100	212,000	7,920	19,200	1,560	180	738,820
1982	6	397,860	120,120	212,000	9,500	19,200	1,870	120	760,670
1983	7	397,860	140,130	212,000	11,080	19,200	2,190	90	782,550
1984	8	397,860	160,160	212,000	12,680	19,200	2,490	90	804,480
1985	9	397,860	180,180	212,000	14,260	19,200	2,810	120	826,440
1986	10	397,860	200,200	212,000	15,840	19,200	3,120	90	848,310
1987	11	--	200,200	--	15,840	--	3,120	90	219,250
1988	12	--	200,200	--	15,840	--	3,120	120	219,280
1989	13	--	200,200	--	15,840	--	3,120	90	219,250
1990	14	--	200,200	--	15,840	--	3,120	90	219,250
1991	15	--	200,200	--	15,840	--	3,120	120	219,280
1992	16	--	200,200	--	15,840	--	3,120	90	219,250
1993	17	--	200,200	--	15,840	--	3,120	90	219,250
1994	18	--	200,200	--	15,840	--	3,120	120	219,280
1995	19	--	200,200	--	15,840	--	3,120	90	219,250
1996	20	--	200,200	--	15,840	--	3,120	90	219,250
1997	21	--	200,200	--	15,840	--	3,120	120	219,280
1998	22	--	200,200	--	15,840	--	3,120	90	219,250
1999	23	--	200,200	--	15,840	--	3,120	90	219,250
2000	24	--	200,200	--	15,840	--	3,120	120	219,280
Total		$3,978,600	$3,903,880	$2,120,000	$308,880	$192,000	$60,840	$3,210	$10,567,410
24-Year Average		$ 165,770	$ 162,660	$ 88,330	$ 12,870	$ 8,000	$ 2,540	$ 134	$ 440,300

Table 42 (continued)

Calendar Year	Project Year	Floodland Management Element: Channel Modifications: Construction	Channel Modifications: Operation and Maintenance	Detention Storage: Construction	Detention Storage: Operation and Maintenance	Structure Floodproofing and Removal	Bridge Modification for Flood Control Purposes	Stream Gaging Network: Operation and Maintenance of Continuous Recorder Gages[h]	Stream Gaging Network: Installation of Staff or Crest Stage Gages[i]	Industrial Valley Measures[j]	Subtotal
1977	1	$ 2,106,100	$ 1,700	$126,000	$ 1,200	$ 887,500	$ 42,000	$ --	$450	$162,600	$ 3,327,550
1978	2	2,106,100	3,400	126,000	2,500	887,500	42,000	6,400	--	162,600	3,336,500
1979	3	2,106,100	5,200	126,000	3,700	887,500	42,000	6,400	--	162,600	3,339,500
1980	4	2,106,100	6,900	126,000	5,000	887,500	42,000	6,400	--	162,600	3,342,500
1981	5	2,106,100	8,600	126,000	6,200	887,500	42,000	6,400	--	162,600	3,345,400
1982	6	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1983	7	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1984	8	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1985	9	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1986	10	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1987	11	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1988	12	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1989	13	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1990	14	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1991	15	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1992	16	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1993	17	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1994	18	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1995	19	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1996	20	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1997	21	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1998	22	--	8,600	--	6,200	--	--	6,400	--	--	21,200
1999	23	--	8,600	--	6,200	--	--	6,400	--	--	21,200
2000	24	--	8,600	--	6,200	--	--	6,400	--	--	21,200
Total		$10,530,300	$189,200	$630,100	$136,400	$4,437,300	$210,000	$147,200	$450	$813,000	$17,093,950
24-Year Annual Average		$ 438,800	$ 7,900	$ 26,300	$ 5,700	$ 184,900	$ 8,800	$ 6,100	$ 18	$ 33,900	$ 712,200

Calendar Years	Project Years	Water Quality Management Element: Abate Creosote Pollution With Excavation of New Channel and Filling of Existing Channel (Construction)	Control Runoff from Animal Feedlots (Construction)	Reduce Diffuse Source Pollution from Agricultural Lands	Reduce Diffuse Source Pollution from Urban Lands (Operation and Maintenance)	Subtotal	Total
1977	1	$ 40,200	$ 80,000	$ 46,080	$ 429,000	$ 595,280	$ 4,574,130
1978	2	40,200	80,000	46,080	429,000	595,280	4,604,940
1979	3	40,200	80,000	46,080	429,000	595,280	4,629,820
1980	4	40,200	80,000	46,080	429,000	595,280	4,654,720
1981	5	40,200	80,000	46,080	429,000	595,280	4,679,500
1982	6	--	--	--	429,000	429,000	1,210,870
1983	7	--	--	--	429,000	429,000	1,232,750
1984	8	--	--	--	429,000	429,000	1,254,680
1985	9	--	--	--	429,000	429,000	1,276,640
1986	10	--	--	--	429,000	429,000	1,298,510
1987	11	--	--	--	429,000	429,000	669,450
1988	12	--	--	--	429,000	429,000	669,480
1989	13	--	--	--	429,000	429,000	669,450
1990	14	--	--	--	429,000	429,000	669,450
1991	15	--	--	--	429,000	429,000	669,480
1992	16	--	--	--	429,000	429,000	669,450
1993	17	--	--	--	429,000	429,000	669,450
1994	18	--	--	--	429,000	429,000	669,480
1995	19	--	--	--	429,000	429,000	669,450
1996	20	--	--	--	429,000	429,000	669,450
1997	21	--	--	--	429,000	429,000	669,480
1998	22	--	--	--	429,000	429,000	669,450
1999	23	--	--	--	429,000	429,000	669,450
2000	24	--	--	--	429,000	429,000	669,480
Total		$201,000	$400,000	$230,400	$10,296,000	$11,127,400	$38,788,760
24-Year Annual Average		$ 8,400	$ 16,700	$ 9,600	$ 429,000	$ 463,700	$ 1,616,200

Table 42 (continued)

[a] *Assumes that 10 percent of the recommended 6.3 square miles of primary environmental corridor land would be acquired in each of the first 10 years of plan implementation.*

[b] *Based on annual operation and maintenance cost of $50 per acre for corridor land.*

[c] *Assumes that 10 percent of the recommended 13.2 miles of new parkway drive would be constructed in each of the first 10 years of plan implementation.*

[d] *Based on annual operation and maintenance costs of $1,200 per mile for parkway drives. (Includes snow removal, grass cutting, and sealing of surface.)*

[e] *Assumes that 10 percent of the recommended 5.2 miles of new recreational trails would be constructed in each of the first 10 years of plan implementation.*

[f] *Based on annual operation and maintenance costs of $600 per mile for recreational trails.*

[g] *Assumes that a total of the signs per mile at a cost of $30 per sign would be installed over a five year period on 20.1 miles of scenic drive and interconnecting urban street and that 10 percent of the signs would be replaced each year.*

[h] *Two continuous stage recorder installations each having a total operation and maintenance cost of $3,200 per year.*

[i] *Nine staff or crest stage gages—one in the City of Mequon in Ozaukee County, two in the Village of Germantown in Washington County, and three in the City of Brookfield and one in the Village of Elm Grove and two in the Village of Menomonee Falls in Waukesha County—at $50 per installation.*

[j] *Assumes a two foot increase in the height of 0.70 mile of earthen dike along the Menomonee River in the vicinity of the Chicago, Milwaukee, St. Paul, and Pacific Railroad property at $70 per lineal foot; a four foot increase in the height of 0.24 mile of floodwall along the east bank of the Menomonee River between the East-West Freeway and the W. Wisconsin Avenue viaduct at $140 per lineal foot; a four foot increase in the height of 0.16 mile of floodwall along the east bank of the Menomonee River between the W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 4.24 at $140 per lineal foot; and a four foot increase in the height of 0.35 mile of floodwall along parts of both banks of the Menomonee River between the railroad bridge and N. 45th Street at $140 per lineal foot. The estimated capital cost of the total 1.45 miles of dike-floodwall extension is $813,000.*

Source: SEWRPC.

acquire and provide access to the necessary open space lands while these lands are still in predominantly rural use and before they are preempted by urban development. The total capital land acquisition and construction costs and operation and maintenance cost for the recommended land use plan element is $10.6 million.

The average annual capital and operation and maintenance costs of implementing the primary environmental corridor subelement are, as noted in Table 42, estimated to be $328,430, or about $0.89 per capita per year. The average annual capital and operation and maintenance costs of implementing the parkway drive-scenic drive-recreational trail subelement are estimated to be $111,870, or about $0.31 per capita per year. Of the total estimated land acquisition, construction, and operation and maintenance costs of $10.6 million for implementation of the land use plan element, about $7.9 million, or about 75 percent, would be expended to implement the primary environmental corridor subelement with the remaining $2.7 million, or about 25 percent, being required to implement the parkway drive-scenic drive-recreational trails sublement.

Floodland Management Plan Element: Table 42 recommends that structural measures required for implementation of the floodland management element of the watershed plan be carried out during the first five years of the plan implementation period. This accelerated construction of structural flood control measures is recommended in order to provide, in the immediate future, relief from the serious flood problems that prevail in portions of the watershed.

The total capital construction cost and operation and maintenance cost for the recommended floodland management plan element in the watershed is $17.1 million. The average annual capital and operation and maintenance costs of implementing the recommended floodland management plan element for the watershed are $712,200, or about $1.94 per capita, which amount would largely be expended for construction of flood control facilities. Of the total estimated cost of $17.1 million for implementation of the floodland management plan element, about $11.7 million, or about 68 percent, would be expended for structural flood control measures—channelization, detention storage, and bridge modification—with the remaining $5.4 million, or 32 percent, being expended for structure floodproofing and removal, stream gaging, and miscellaneous measures in the industrial valley.

Water Quality Management Plan Element: The total capital and operation and maintenance cost for the recommended water quality management plan element is $11.1 million. As noted above, however, this cost does not include the capital cost and operation and maintenance costs of pollution abatement measures recommended in other adopted Commission plans. These measures, the costs of which are not reflected in the cost of the Menomonee River watershed plan, include: trunk sewer construction necessary to permit abandonment of the four remaining municipal sewage treatment plants in the watershed and to facilitate provision of sanitary sewer service to presently unsewered urban areas and to planned urban development; abatement of pollution from sanitary sewer flow relief devices;

and abatement of the combined sewer overflow problem in the Menomonee River watershed. The average annual capital and operation and maintenance costs of implementing the recommended water quality management plan element for the watershed are estimated to be $463,700, or about $1.26 per capita. Of the total estimated cost of $11.1 million for implementation of the water quality management plan element, about $0.2 million, or about 2 percent, would be expended to implement the creosote abatement planned subelement, and about $10.9 million, or about 98 percent, would be expended to implement the land management pollution abatement measures.

Cost of Pollution Abatement Measures Recommended Under the Regional Sanitary Sewerage System Plan to be Implemented Within the Menomonee River Watershed: As noted above, the anticipated capital costs and operation and maintenance expenditures for the water quality management element of the recommended Menomonee River watershed plan exclude the costs of those pollution abatement measures recommended under the regional sanitary sewerage system plan. Those measures, however, would have to be carried out, in part, within the Menomonee River watershed. These pollution abatement measures consist of: construction of facilities for the abatement of the combined sewer overflow problem in the Milwaukee-Metropolitan area; construction of intercommunity trunk sewers needed to provide adequate sanitary sewer service to existing unsewered urban development and to planned new urban development and to permit abandonment of the remaining four municipal sewage treatment plants operating in the watershed and the connection of the tributary service areas to the Milwaukee metropolitan system; and elimination of sanitary sewerage system flow relief devices. Although the regional sanitary sewerage system plan recommends provision of sanitary sewer service to existing and proposed urban development, the cost of the local sanitary sewers needed to implement this recommendation was not included in the adopted regional sanitary sewerage system plan or in the watershed plan since such costs would generally be incurred by private landowners and developers and assessed directly against or otherwise passed on to the purchasers of residential, commercial, and industrial property.

Although the costs of abatement of combined sewer overflows, intercommunity trunk sewer construction, and elimination of flow relief devices within the Menomonee River watershed are not assigned to the comprehensive plan for the Menomonee River watershed, since such costs have already been charged to the regional sanitary sewerage system plan, it is of interest to determine the costs of the in-watershed portion of these previously recommended regional pollution abatement measures and to compare the costs of the in-watershed portion of these pollution abatement measures to the assignable costs of the recommended Menomonee River watershed plan.

The 1970 capital costs of the recommended combination deep tunnel-mined storage-flow through treatment system intended to collect, convey, and adequately treat all combined sewer overflows throughout the 27-square-mile combined sewer service area in Milwaukee County was estimated at $130 million, or approximately $4.8 million per square mile. Similarly, 1970 operation and maintenance expenditures for the recommended combined sewer overflow pollution abatement measure were estimated at $1.56 million per year for the 27-square-mile combined sewer service area or about $58,000 per square mile. As a result of an approximate 50 percent increase in construction and other costs since 1970, the 1975 unit capital cost for the recommended combined sewer overflow abatement measure is estimated at $7.25 million per square mile and the 1975 unit operation and maintenance expenditure is estimated at $87,000 per square mile per year.

Approximately 10.7 square miles of the total 27-square-mile combined sewer service area in the Milwaukee-metropolitan area lies within the Menomonee River watershed. Therefore, the estimated 1975 capital costs of the implementation of the combined sewer overflow abatement measure within the Menomonee River watershed is $77.6 million and the associated estimated operation and maintenance expenditures are $933,000 per year.

The estimated capital costs of trunk sewer construction to be carried out within the Menomonee River watershed, as shown on Map 52, was estimated in 1970 at $19.9 million equivalent to about $29.9 million in 1975. Similarly, the attendant operation and maintenance expenditures for the in-watershed portion of the trunk sewer construction recommended, under the regional sanitary sewerage system plan was estimated in 1970 as $3,430 per year, equivalent to approximately $5,150 per year in 1975.

Some of the 102 flow relief devices located directly on, or very close to, the proposed relief sewers within the Menomonee River watershed could be abandoned immediately upon completion of the intercommunity trunk sewer construction and, therefore, there would be no significant additional direct costs associated with the elimination of such flow relief devices as recommended in the regional sanitary sewerage system plan. The cost of structural work required to eliminate the remaining sanitary sewer system flow relief devices is likely to vary widely among the various devices and can be determined only through detailed engineering studies of each device. However, the cost of the necessary structural work on the remaining flow relief devices is likely to be very small compared to the $29.9 million cost of the recommended intercommunity trunk sewer construction and, therefore, may be neglected for purposes of this analysis.

Assuming that the in-watershed portion of the combined sewer overflow abatement facilities is constructed during the 10-year period of 1978 through 1987 and the in-watershed portion of the recommended intercommunity trunk sewer facilities is constructed during the 14-year period of 1977 through 1990, the capital cost and operation and maintenance expenditures during the 24-year Menomonee River watershed plan implementation period for these two pollution abatement plan elements would total $124.9 million or $339 per capita. On an annual basis, these capital and operation and maintenance costs would be $5.2 million per year for the 24-year implementation period, or approximately $14 per capita per year. The total $124.9 million 24-year plan implementation cost of the in-watershed portion of the two pollution abatement measures as recommended under the adopted regional sanitary sewerage system plan is 3.2 times the total $38.8 million 24-year plan implementation costs assigned to the recommended Menomonee River watershed plan.

Comparison of Plan Costs to Selected Recent Public Expenditures

In order to assess the possible impact of implementation of the watershed plan on the public financial resources of local units of government within the watershed, an analysis was made of the recent public expenditures for park and outdoor recreation purposes and for major channel modifications for comparison to the costs associated with the recommended comprehensive plan for the watershed. Recent capital and operation and maintenance expenditures by all units of government within the watershed for park and outdoor recreation purposes were used as an index of the ability of local units of government to expend the funds necessary to implement the primary environmental corridor subelement and the parkway drive-scenic drive-recreational trail subelement of the land use plan element of the Menomonee River watershed plan. Similarly, recent capital expenditures for major channel works by the Milwaukee-Metropolitan Sewerage Commissions were used as an index of the ability of local units of government to expend the funds necessary to implement the structural flood control measures contained within the recommended floodland management plan element of the watershed plan.

Analysis of Recent Park and Outdoor Recreation Expenditures: Expenditures for park and outdoor recreation purposes by the four counties and 17 cities, villages, and towns located wholly or partly within the watershed for the 10-year period from 1963 through 1972 were obtained from the records of the Wisconsin Department of Revenue, Bureau of Municipal Audit. These expenditures are reported in two major categories: capital expenditures, which includes outlays for purposes such as land acquisition and parkway drive construction, and operation and maintenance outlays. These recent park and outdoor recreation expenditures for each of the 21 units of government were apportioned to the watershed based upon the proportion of the total population of each civil division within the watershed to the total population of each civil division. The resulting 1963 through 1972 park and outdoor recreation expenditures by local units of government in the Menomonee River watershed are set forth in Table 43.

Capital expenditures for park and outdoor recreation purposes within the watershed for the 10-year period from 1963 to 1972 totaled $14.5 million, or approximately $1.5 million per year. Operation and maintenance expenditures during this same period totaled $37.5 million, or approximately $3.8 million per year. Total expenditures for park and outdoor recreation purposes by local units of government in the Menomonee River watershed during the 10-year period total $52.0 million, or an average of about $5.2 million per year.

As shown in Table 42, the estimated total cost of implementing the primary environmental corridor subelement and the parkway drive-scenic drive-recreational trails subelement of the recommended watershed plan, including capital and operation and maintenance cost, is estimated at $10.6 million, or $440,300 per year, for the total 24-year plan implementation period. Capital costs for the intensive 10-year land acquisition and parkway drive-recreation trail-scenic drive development phase total about $6.3 million, or about $629,700 per year, with operation and maintenance costs during that period totaling about $1.2 million, or about $120,500 per year. Total costs during the 10-year period in which essentially all of the primary environmental corridor and parkway drive-scenic drive-recreational trail implementation efforts would occur and, in which 71 percent of the expenditures would occur, total about $7.5 million, or about $750,200 per year.

Table 43

PARK AND OUTDOOR RECREATION EXPENDITURES BY LOCAL UNITS OF GOVERNMENT IN THE MENOMONEE RIVER WATERSHED: 1963-1972

Year	Expenditures in Millions of Dollars		
	Capital[a,b]	Operation and Maintenance[b]	Total
1963	1.4	2.1	3.5
1964	3.6	2.6	6.2
1965	1.0	3.0	4.0
1966	1.5	3.3	4.8
1967	2.1	3.8	5.9
1968	2.0	4.6	6.6
1969	0.5	4.0	4.5
1970	1.0	3.8	4.8
1971	1.0	5.2	6.2
1972	0.4	5.1	5.5
Total	14.5	37.5	52.0[c]
10-Year Average	1.5	3.8	5.2

[a] *Includes expenditures reported for such purposes as land acquisition and parkway drive construction.*

[b] *Excludes park and recreation-related expenses by the City of Milwaukee school system.*

[c] *About 92 percent of these expenditures occurred in the Milwaukee County portion of the watershed.*

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

This latter annual amount may be compared to the recent average annual expenditures for park and outdoor recreation purposes in the Menomonee River watershed. Such a comparison indicates that substantially more money would probably be available within the watershed to undertake programs consistent with plan implementation than would be needed. For example, recent actual capital and operation and maintenance expenditures for park and outdoor recreation purposes within the watershed have been about $5.2 million per year whereas scheduled capital and operation and maintenance expenditures during the 10-year intensive implementation period of 1977 through 1986 are estimated at about $0.75 million per year. Therefore, recent average annual expenditures for park and outdoor recreation purposes have been approximately seven times that needed to implement essentially all of the recommendations concerning primary environmental corridors and parkway drive-scenic drive-recreational trails within the watershed. After the 10-year implementation period, that is, from 1987 through 2000, it is anticipated that no major expenditures will be required for open space land acquisition or for parkway drive-recreational trail construction.

It is important to note that although a projection of historic park and recreation expenditures within the watershed indicates that sufficient funds should be available on a watershedwide basis to undertake programs consistent with plan implementation, a shift in the geographic focus of the expenditures and therefore source of the necessary funds will have to be effected. Of the total of $52.0 million expended in the watershed for park and recreation purposes during the 10-year period from 1963 through 1972, $47.8 million, or 92 percent, was expended within the Milwaukee County portion of the basin. In contrast, of the total of $10.6 million capital and operation and maintenance expenditures scheduled for implementation of the primary environmental corridor subelement and the parkway drive-scenic drive-recreational trails subelement of the recommended watershed plan, $9.0 million, or 85 percent, must be expended in the Ozaukee, Washington, and Waukesha Counties portions of the watershed with the remaining 15 percent being expended within the Milwaukee County portion of the basin.

Analysis of Recent Channel Improvement Expenditures: Capital expenditures for channel modifications, excluding bridge demolition and reconstruction, within the Milwaukee County portion of the Menomonee River watershed for the 13-year period of 1960 through 1973 were obtained from the Milwaukee-Metropolitan Sewerage Commissions. These public capital expenditures relate to major channel modifications carried out on portions of Honey Creek, Underwood Creek, and the main stem of the Menomonee River during that 13-year period. Although channel alterations, such as those within the Village of Elm Grove, were also carried out at public cost in other parts of the watershed during that period, the capital costs of those projects are small compared to capital costs of channel modifications within the Milwaukee County portion of the watershed; therefore, the latter expenditures are a sufficiently accurate index of recent channel modification expenditures within the watershed. The channel modification expenditures for the Milwaukee County portion of the watershed, as set forth in Table 44, indicate that over the 13-year period a total of approximately $13.3 million was expended on channel improvements in the Milwaukee portion of the watershed, or an average of approximately $1.0 million per year.

As shown in Table 42, the estimated total capital cost of implementing the floodland management element of the Menomonee River watershed plan is $17.1 million with $11.7 million, or 68 percent of the total estimated cost, being assigned to structural measures such as channel modifications, detention storage, and bridge replacement. The $11.7 million capital cost for structural measures would be expended during the intensive five-year implementation phase at about $2.34 million dollars per year.

This latter amount may be compared with recent capital expenditures by the Milwaukee-Metropolitan Sewerage Commissions for channel modification. Actual recent expenditures for channel modifications within the watershed, exclusive of bridge demolition and reconstruction costs, have approximated$1.0 million per year, whereas scheduled expenditures during the five-year

Table 44

CHANNEL MODIFICATION CAPITAL EXPENDITURES BY THE MILWAUKEE-METROPOLITAN SEWERAGE COMMISSIONS IN THE MENOMONEE RIVER WATERSHED 1960-1973

Year	Expenditures in Thousands of Dollars[a]			
	Honey Creek	Underwood Creek	Menomonee River	Total
1960	88	--	--	88
1961	--	--	--	--
1962	--	--	663	663
1963	--	--	--	--
1964	511	--	--	511
1965	1,889	522	--	2,411
1966	2,176	--	--	2,176
1967	1,729	--	--	1,729
1968	9	--	1,455	1,464
1969	199	410	--	609
1970	--	1,607	--	1,607
1971	--	--	--	--
1972	--	--	--	--
1973	909	1,135	--	2,044
Total	7,510	3,674	2,118	13,302
13-Year Average	578	282	163	1,023

[a] *Excludes the cost of bridge demolition and reconstruction.*

Source: Milwaukee-Metropolitan Sewerage Commissions.

intensive implementation period of 1977-1981 for structural flood control works are estimated at $2.34 million per year. Therefore, recent annual public capital expenditures for channelization only and for such channelization only in the Milwaukee County portion of the watershed have been about 43 percent of the annual capital expenditures required over the five-year implementation period of 1977 through 1981 to construct all the recommended structural flood control works. After that period, that is, from 1982 through 2000, it is anticipated that no major structural flood control works will be required within the Menomonee River watershed.

Concluding Statement: The cost analysis conducted under the Menomonee River watershed program does not include the comparison of cost associated with implementing the water quality management plan element and the recent public expenditures for pollution abatement. Most of the water quality management subelements recommended under the Menomonee River watershed planning program were previously recommended under the adopted regional sanitary sewerage system plan and, under that planning program, analyses were conducted to demonstrate that sufficient funds would be available to implement the recommended pollution abatement measures.

From the foregoing discussion, it is fair to conclude that sufficient monies to implement substantially the recommended land use plan element, the floodland management plan element, and the water quality management plan element of the comprehensive Menomonee River watershed should become available within the watershed, although the current rate of expenditures for flood control improvements would have to be increased to permit implementation of the floodland management element of the plan in the first five years. However, significant shifts may be required with respect to where within the watershed such expenditures have been made in the past and where they must be made in the future. The cost of implementing the watershed plan over the 24-year plan implementation period would be reasonably achievable by continuing the approximate current public expenditure patterns for park and outdoor recreation purposes, flood control, and pollution abatement. It is clear that if the adopted watershed development objectives and standards are to be met, and if the associated desired environmental quality within the watershed is to be achieved and maintained, the level of expenditures needed to implement the recommended watershed plan is necessary and fully warranted.

THE ABILITY OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED TO MEET ADOPTED OBJECTIVES AND STANDARDS

In its most basic sense, planning is a rational process for establishing and meeting objectives. The objectives which have been adopted for the Menomonee River watershed constitute the overall goals of the comprehensive plan. As discussed in Chapter II, Volume 2 of this report, the formulation of watershed development objectives and supporting standards was undertaken early in the Menomonee River watershed study as the second step in the seven-step planning process.

Chapter II of this volume sets forth the regional land use and sanitary sewerage system planning objectives, principles, and standards which had been adopted by the Commission under related regional planning programs at the time of initiation of the Menomonee River watershed planning program, and which are related to formulation of a comprehensive plan for the Menomonee River watershed. Chapter II also presents a series of water control facility development objectives and standards based on similar objectives and standards formulated under earlier Commission watershed studies revised as needed to meet the needs of the Menomonee River watershed. Therefore, the objectives and standards established for the Menomonee River watershed planning program consist primarily of objectives and standards adopted under related planning programs supplemented with objectives and standards developed under the Menomonee River watershed planning program.

The adopted watershed development objectives have been translated into adopted detailed design standards in order to provide the basis for plan preparation, test, and evaluation. More specifically, the adopted objectives and supporting standards have been used to prepare and evaluate alternative subelements within three major plan elements: the land use plan element, the floodland management plan element, and the water quality management plan element. The preparation and evaluation of alternative plan subelements within the above three categories resulted in the synthesis of a recommended comprehensive plan for the Menomonee River watershed.

It is appropriate to determine how well the recommended comprehensive plan for the watershed meets the adopted objectives and standards. Accordingly, an evaluation of the comprehensive plan was made on the basis of its ability to meet the watershed development objectives and standards. The results of that evaluation are presented in summary form in Table 45.

Although all the standards appearing in the table are not of equal value, a determination of what portion of the standards are classified as "met," "could be met," "not applicable," "partially met," or "cannot be met" provides a general evaluation of the ability of the comprehensive plan for the Menomonee River watershed to meet the adopted objectives and standards.

Of the 79 standards appearing in Table 45, 32, or 41 percent are rated as "met," and an additional 28, or 35 percent are classified as "could be met." A total of 11, or 14 percent of the standards are categorized as "not applicable" and only 8, or 10 percent of the standards are rated as "partially met," "cannot be met," or "not met." The relatively small number of standards that could not be met or would be only partially met under the recommended comprehensive plan for the Meno-

Table 45

ABILITY OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED TO MEET ADOPTED OBJECTIVES AND STANDARDS

Land Use Objectives

Objective Number	Objective Description	Standard		Degree to Which Standard is Met	Comments
1	A balanced allocation of space to the various land use categories which meets the social, physical, and economic needs of the regional population	Residential Land Allocation	Rural—1,429 acres/1,000 added persons	Not applicable	Land use plan proposes new medium density urban areas. No new suburban, low, or rural density areas are planned
			Suburban—572 acres/1,000 added persons	Not applicable	
			Low-density Urban—238 acres/1,000 added persons	Not applicable	
			Medium-density—65 acres/1,000 added persons	Met	Standard requires 2,600 acres and plan proposes 6,420 acres
			High-density—24 acres/1,000 added persons	Not applicable	--
		Government and Institutional Land Allocation	9 acres/1,000 added population	Met	Standard requires 360 acres and plan proposes 416 acres.
		Park and Recreation Land Allocation	Local—9 acres/1,000 added population	Met	Standard requires 360 acres which is easily met by combination of 3,070 acres of recommended primary environmental corridor acquisition and allowance for local park in each quarter section of new residential development
			Regional—4 acres/1,000 added population	Cannot be met in watershed	Regional parks are not proposed due to lack of suitable sites
			Swimming—0.45 acre beach/100 participants	Met	Standard met by equivalent swimming pools
			Picnicking—12.5 acres/100 participants	Met	2,730 acres of existing picnicking lands are sufficient to meet existing and forecast demand for year 2000
			Golfing—32.8 acres/100 participants	Met	Sufficient land available for the public or private development of additional golf courses in urbanizing areas
			Camping—133.3 acres/100 participants	Cannot be met	No potential for development of quality camping areas
			Snowskiing—3.7 acres/100 participants	Could be met	Significant land available for the public or private development of the necessary additional skiing slopes and facilities
		Commercial Land Allocation	3 acres/100 added employees	Not met	Standard requires 642 acres acres and plan proposes 180 acres
		Industrial Land Allocation	2 acres/100 added employees	Met	Standard requires 412 acres and plan proposes 787 acres

Table 45 (continued)

Land Use Objectives

Objective Number	Objective Description	Standard		Degree to Which Standard is Met	Comments
2	A spatial distribution of the various land uses which will result in the protection, wise use, and development of the natural resources of the Region	Soils	Urban Uses	Met[a]	--
			Rural Uses	Met[a]	--
			Sanitary Sewer Service Areas	Not applicable	Plan does not propose land to be developed without sanitary sewer service
		Wetlands	Protect wetlands over 50 acres and those with high resource values	Met[a]	All of the 12 wetlands 50 acres or more in size are protected under the recommended PEC subelement
		Woodlands	10 percent of watershed	Cannot be met	Requires 13.7 square miles of woodland in watershed compared to existing 5.3 square miles of woodland
			40 acres each of 4 forest type	Partially met	--
			5 acres/1,000 regional population	Met	--
		Wildlife	Maintain a wholesome habitat	Could be met	Largely dependent on local community action with respect to habitat management
3	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 economical provision of utility and municipal services	Major transportation routes to avoid penetration of natural resource areas		Could be met	--
		Transportation systems to provide access to urban areas		Could be met	--
		Sewer service to residential areas		Met[a]	--
		Water supply to residential areas		Could be met	Dependent upon results of current study of inter-municipal intersupply system
		Maximize use of existing transportation and utility facilities		Met[a]	--
4	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 recreational program providing a full range of facilities for all age groups	Local park spacial location		Could be met	Plan allows for local park in each quarter section of new urban development
		Regional park spacial location		Met	Regional park and recreation areas available inside and surrounding the watershed
		Areas of scientific, cultural scientific, and educational value		Met	Incorporated in primary environmental corridor

Table 45 (continued)

Land Use Objectives

Objective		Standard	Degree to Which Standard is Met	Comments
Number	Description			
5	The preservation of land areas for agricultural uses in order to provide for certain special types of agriculture, provide a reserve 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	Preserve prime agricultural lands	Partially met	About 75 percent of prime agricultural lands retained in year 2000 plan
		Preserve other appropriate agricultural areas	Met	Such areas are protected under recommended primary environmental corridor subelement
6	The attainment of good soil and water conservation practices in order to reduce storm water runoff, soil erosion, and stream and lake sedimentation, pollution, and eutrophication	Conservation treatment on agricultural lands	Could be met	--
		Protect drainageways from erosion	Could be met	--
		Protect developing urban lands from erosion	Could be met	--
		Central erosion in critical areas	Could be met	--

Sanitary Sewage System Objectives

Objective		Standard	Degree to Which Standard is Met	Comments
Number	Description			
1	The development 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 sanitary waste disposal demand generated by the existing proposed land uses.	Sanitary sewer service to medium and high density urban development.	Met[a]	--
		Sanitary sewer service to low density urban development	Not applicable	Plan does not contain significant low density areas
		Sanitary sewer serivce in poor soil areas	Met[a]	--
		Sanitary sewer service not provided to primary environmental corridors	Met[a]	--
		Sanitary sewer service not provided to floodlands	Met[a]	--
		Sanitary sewer service restricted in areas of soils with very severe limitations for urban development	Met[a]	--
		Orderly extension of sanitary sewage facilities	Could be met	--
		Sizing of sewerage facility components in accordance with land use plan	Could be met	--
		Treatment and disposal of industrial wastes	Could be met	--
2	The development of sanitary sewerage systems that are properly related to, and that will enhance the overall quality of, the natural and man-made environments	New and replacement location of sewage treatment plants outside of 100-year floodplain	Not applicable	--
		Floodproofing sewage treatment plants located in 100-year floodplain	Not applicable	--
		Location of new and replacement sewage treatment plants relating to proposed urban development	Not applicable	--
		Sewage treatment plant sites to supply adequate open space	Not applicable	--
		Disposal of sludge from sewage treatment plants	Not applicable	--
3	The development of sanitary sewerage systems that are both economical and efficient, meeting all other objectives at the lowest cost possible	Minimize investment and operating costs of sanitary sewerage systems	Could be met	--
		Minimize number of sanitary sewerage systems and sewage treatment facilities	Could be met	--
		Maximize feasible use of sanitary sewerage facilities	Could be met	--
		Use of new and improved materials and management practices	Could be met	--
		Staged or incremental construction of sanitary sewage facilities	Could be met	--
		Minimize land acquisition costs for new sewer construction	Could be met	--
		Minimize clear water inflows and infiltrated into sanitary sewerage system	Could be met	--
		Integrated design of sanitary and storm sewer systems	Could be met	

Table 45 (continued)

Water Control Objectives

Objective Number	Objective Description	Standard		Degree to Which Standard is Met	Comments
1	An integrated system of drainage and flood control facilities and floodland management programs which will effectively reduce flood damage under the existing land use pattern of the watershed and promote the implementation of the watershed land use plan, meeting the anticipated runoff loadings generated by the existing and proposed land uses.	New and replacement bridges and culverts.	Minor streets - pass the 10-year flood	Met	--
		(continued)	Arterial streets and highways - pass the 50-year flood	Met	--
		(continued)	Freeways and expressways - pass the 100-year flood	Met	--
		New or replacement bridges and culverts shall pass the 100-year flood without reaching the peak stage more than 0.5 foot		Met	--
		Structure design shall maximize passage of ice flow and debris		Met	--
		Certain new and replacement bridges and culverts shall pass the 100-year flood with 2.0 feet of free board.		Met	--
		Existing bridges and culverts to meet standards 1, 3, and 4 above		Met	--
		Channel improvements should be restricted to the absolute minimum necessary		Met	--
		The height of dikes and floodwalls shall pass the 100-year flood with 2.0 feet of freeboard		Met	--
		The construction of channel modifications, dikes, or floodwalls to change limits of regulatory floodlands		Could be met	--
		Upon completion of the construction of reservoirs and diversions, regulatory floodland limits will be changed		Could be met	--
		All other water control facilities such as dams or diversion channels shall accommodate the 100-year flood		Met	--
		Public land acquisition to eliminate water control facilities shall encompass the entire 100-year floodplain		Met	--
		Regulatory floodways shall accommodate existing committed and planned floodplain land uses		Could be met	--
		Floodway stage increase limited to 0.5 foot based on equal degree of encroachment concept		Could be met	--
2	An integrated system of land management and water quality control facilities and pollution abatement devices adequate to assure a quality of surface water necessary to meet the desired uses	Satisfy established water quality standards		Partially met	--
		Low flow criteria is basis for evaluating conformance with water quality standards		Partially met	--
3	The attainment of sound ground water resource development and protective practices to minimize the possibility for pollution and depletion of the ground water resources.	Relate ground water withdrawal rates to potential yields and total demand on aquifer		Could be met	--
		Avoid contamination of aquifer during well construction and operation		Could be met	--
		Prevent infiltration of contaminants from waste disposal facilities into sources of usable ground water		Could be met	--

[a] *This standard has been met under the recommended land use and/or regional sanitary sewerage system plans because it served as an input to the plan design process.*

Source: SEWRPC.

monee River watershed support objectives that are inextricably related to the underlying natural resource base and the failure to fully meet those standards reflects the already deteriorated condition of the underlying natural resource base of this urbanizing watershed. As discussed in detail in Chapter IX, Volume 1 of this report, it appears physically impossible to fully achieve some of the standards because the necessary natural resource base elements are no longer present in sufficient quantity and quality.

In summary, the recommended watershed plan could result in substantial achievement of the adopted watershed development objectives and standards and, as a result, implementation of the plan may be expected to provide a safer, more healthful, and more pleasant, as well as a more orderly and efficient environment for all life within the watershed. Implementation of the recommended watershed plan would abate many of the existing areawide developmental and environmental problems, would avoid development of new problems, and would do much to protect and enhance the underlying and sustaining natural resource base.

CONSEQUENCES OF NOT IMPLEMENTING THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED

Within the framework of the overriding goals of the Menomonee River watershed planning program—that is, the adopted objectives and standards—it is likely that the recommended comprehensive plan for the basin approaches the optimum or best combination of measures for 1) resolving the water resource and water resource-related problems such as flooding, water pollution, diminishing quality of the natural resource base, and changing land use that presently plague the Menomonee River watershed and 2) preventing aggravation of the existing problems or the development of new environmental problems within the basin. This is so because preparation of the recommended comprehensive plan for the Menomonee River watershed involved the conduct of extensive inventories; application of state-of-the-art analytic tools; exhaustive examination of alternative subelements including evaluation of the technical, economic, and environmental impacts of each; preparation of a plan implementation strategy and capital and operation and maintenance expenditure schedule; consideration of public views and concerns in the form of public informational meetings and formal hearings; and several years of the deliberation by the Menomonee River Watershed Committee.

In the absence of a sound comprehensive watershed plan which approaches the optimum combination of measures to achieve the stated objectives, a multitude of incorrect decisions is likely to be made and courses of action are likely to be followed that will lead to the aggravation of existing water resource and water resource-related problems as well as the development of new problems. Inasmuch as the comprehensive plan for the Menomonee River watershed seeks to identify those courses of action most likely to result in the rational, most cost-effective, and lasting solutions to the water resource and water resource-related problems of the watershed and the prevention of future problems, it is appropriate to identify, and, where feasible, to quantify the consequences of not adopting and implementing the recommendations contained within the comprehensive plan for the Menomonee River watershed. The analysis of the consequences of not adopting and implementing the watershed plan has a negative aspect in that it identifies water resource and water resource-related problems that may be expected to occur or be aggravated within the watershed in the absence of watershed plan implementation. The analysis is positive or constructive, however, in that it is intended to support and reinforce the need for implementation of the recommended rational, long-range, comprehensive plan for the urbanizing Menomonee River watershed. As suggested by the analysis, early and vigorous implementation of the recommended watershed plan is particularly critical to the Menomonee River watershed because this small basin is—relative to most other watersheds in southeastern Wisconsin—already extensively urbanized. Moreover, further unplanned development over the next few decades can result in complete urbanization of the Menomonee River watershed with the attendant aggravation of existing developmental and environmental problems and development of new water resource and water resource-related problems.

The analysis of the likely consequences of not implementing the recommended comprehensive plan for the Menomonee River watershed is based primarily on two sources of information: 1) the data collected and the analyses conducted under the Menomonee River watershed planning program and 2) empirical information derived from observation of water resource and water resource-related problems that already exist within the seven-county planning Region and which have been the subject of other Commission plan and plan implementation activities. An example of an analysis which was conducted under the Menomonee River watershed planning program and which provides insight into the consequences of not implementing the land use plan is the simulation study of the impact of uncontrolled urban sprawl on monetary flood damages in the basin. An example of empirical information derived from observations of water resource and water resource-related problems outside of the Menomonee River watershed which may be used to assess the likely consequences of not implementing the Menomonee River watershed plan is provided by the failure of the governmental agencies concerned to remove flood-prone structures and to control development in a known flood hazard area along the North Branch of the Root River, as recommended in the adopted Root River watershed plan, resulting in the construction of additional flood-prone residences and the continuance and aggravation of a serious flood problem.

The likely consequences of not implementing the recommended comprehensive plan for the Menomonee River watershed are summarized in Table 46. Within the overall framework of the three basic plan elements—the land use plan element, the floodland management plan element, and the water quality plan element—Table 46 identifies each plan subelement and some likely negative consequences of failure to implement those subelements.

Land Use Plan Element

The highly diffuse, low to medium density urban development likely to be attendant to failure to implement the overall land use plan may be expected to result in increased costs, relative to those which would occur under planned land use, of public utilities and services such as sanitary sewerage, water supply, transportation, and police and fire protection. It is likely that uncontrolled urbanization like that expected in the absence of implementation of an overall land use plan would result in loss of most of the prime agricultural lands that remain in the watershed. Furthermore, flood flow simulation model studies indicate that failure to implement the overall land use plan may, because of the direct and significant relationship between incremental urbanization and flood flows, result in up to a six-fold increase in peak

Table 46

PROBABLE CONSEQUENCES OF NOT IMPLEMENTING THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED

Plan Element	Plan Subelement	Probable Negative Consequences of Failure to Implement Plan Recommendations
Land Use	Overall Land Use Plan	● Increased cost of public utilities and services such as sanitary sewerage, water supply, transportation, police, and fire protection. ● Loss of most remaining prime agricultural lands. ● Up to a six-fold increase in 100-year flood flows, up to a nine foot increase in 100-year flood stages, and up to a four-fold increase in average annual flood damages. ● Essentially all of the negative consequences discussed below since most are inextricably related to the land use plan.
	Primary Environmental Corridor	● Loss of recreational, aesthetic, ecologic, and cultural values found in essentially natural unprotected riverine lands and associated woodland, wetland, and wildlife habitat areas. ● Urban development will occur in lands that are wet, flood-prone, and otherwise unsuited for urban development.
	Parkway Drives, Scenic Drives, Recreational Trails	● Prevent full public use and enjoyment of primary environmental corridor lands.
Floodland Management	Flood Control Measures for:	
	Elm Grove	● Continuation of average annual flood damage risk of $231,800 or more under existing conditions.
	Wauwatosa	● Continuation of average annual flood damage risk of $229,000 or more under existing conditions.
	Brookfield	● Continuation of average annual flood damage risk of $59,200 or more under existing conditions.
	Mequon	● Continuation of average annual flood damage risk of $2,300 or more under existing conditions.
	Milwaukee	● Continuation of average annual flood damage risk of $38,600 or more under existing conditions.
	Menomonee Falls	● Continuation of average annual flood damage risk of $69,300 or more under existing conditions.
	Bridge Replacement (for Transportation Purposes)	● Interference with operation of highway and railroad facilities during flood events.
	Land Use Controls:	
	Floodland Regulations	● Increased flood losses due to construction of new flood-prone structures. ● Aggravation of upstream and downstream flood problems due to loss of conveyance and storage resulting in up to an approximately two-fold increase in average annual flood damages. ● Loss of critical portions of primary environmental corridors.
	Control of Land Use Outside of Floodlands	● Increased runoff to the stream system resulting in up to an approximately three-fold increase in average annual flood damages.

Table 46 (continued)

Plan Element	Plan Subelement	Probable Negative Consequences of Failure to Implement Plan Recommendations
Floodland Management (Con'd)	Flood Insurance	● Large monetary losses absorbed by owners of flood-prone structures and property.
	Lending Institution and Realtor Policies	● Acquisition of flood-prone lands and structures by unwary buyers.
	Community Utility Policies	● Tacit approval of urban development in flood-prone lands and in primary environmental corridors.
	Emergency Procedures	● Damage to property and risk to property owners due to inadequate information about floods already in progress.
	Stream Gaging Network	● Lack of critical flow data on actual flood events for use in monitoring urbanization effects and in eventually refining simulation models.
	Industrial Valley Measures	● Inundation of high value industrial-commercial lands and temporary disruption of production and full-scale employment.
Water Quality Management	Municipal Sewage Treatment Plant Abandonment[a]	● Large nutrient load to main stem of the Menomonee River.
	Combined Sewer Overflow Abatement[a]	● Continuation of approximately 50 combined sewer overflows per year to the five mile long portion of the Menomonee River downstream of Hawley Road with resultant inorganic, organic, nutrient, pathogenic, and aesthetic pollution.
	Sanitary Sewer Flow Relief Device Abatement[a]	● Localized public health hazards and objectionable in-stream aesthetic conditions.
	Industrial Discharge Abatement	● Localized pollution problems.
	Sanitary Sewer Service to All Existing and New Urban Development[a]	● Localized and instream health hazards and localized objectionable aesthetic conditions.
	Excavation-Filling Technique to Abate Creosote Pollution	● Continued threat to health of people and of aquatic flora and fauna.
	Feedlot Runoff Control Measures	● Localized instream health hazards and objectionable aesthetic conditions.
	Rural and Urban Diffuse Source Pollution Control Measures	● Continued watershed-wide surface water quality degradation during and immediately after runoff events.

[a] *Recommended in the adopted regional sanitary sewerage system planning program and endorsed under the Menomonee River watershed planning program.*

Source: SEWRPC.

flood discharges, up to a nine foot increase in peak flood stages, and up to an approximately four-fold increase in average annual flood losses.

If the primary environmental corridor subelement is not implemented, the overall quality of life within the basin will be significantly diminished because of the loss of the recreational, aesthetic, ecologic, and cultural values found in essentially natural unprotected riverine lands and associated woodland, wetland, and wildlife habitat areas which comprise the primary environmental corridors. In addition, it is likely that failure to implement the primary environmental corridor subelement will result in widespread encroachment of urban development into riverine lands that are wet, flood-prone, and otherwise unsuited for such development. Failure to implement the parkway drive-scenic drive-recreational trail subelement of the land use plan element will prevent convenient public access to, and use of, primary environmental corridor lands.

Floodland Management Element

Key components of the floodland management plan element for the Menomonee River watershed are structural and nonstructural flood control measures recommended for the Villages of Elm Grove and Menomonee Falls and the Cities of Wauwatosa, Brookfield, Mequon, and Milwaukee. Failure to implement these recommended measures means continuation of average flood damage risks of $600,000 per year for the affected six communities under existing land use-floodland development conditions. Without the recommended flood control measures, a 100-year recurrence interval flood event occurring under existing conditions in each of the six communities could be expected to cause the following monetary flood damages: $1.4 million in the Village of Elm Grove, $340,000 in the City of Brookfield, $380,000 in the Village of Menomonee Falls, $16,000 in the City of Mequon, $730,000 in the City of Milwaukee, and $2.5 million in the City of Wauwatosa.

If the bridge replacement recommendations—for transportation purposes—are not carried out during the plan design period, there may be expected to be a continued and increased interference with the safe and efficient operation of highway and railroad facilities during flood events. Failure to implement the recommended floodland regulations and other land use controls may be expected to cause increased monetary flood losses due to construction of flood-prone structures; aggravation of upstream and downstream flood problems due to loss of conveyance and storage (even if new floodland residential, commercial, and industrial development is adequately flood-protected, analyses indicate that watershedwide floodland development may be expected to result in up to an approximately two-fold increase in average annual flood damages to existing development); and loss of critical portions of the primary environmental corridors. Failure to control the use of land outside of the floodlands—assuming that land use is controlled within the floodlands—may be expected to result in up to an approximately three-fold increase in average annual flood damages in the watershed.

If watershed residents do not avail themselves of the opportunity to acquire flood insurance available under the federal program, the monetary losses resulting from future floods will have to be absorbed entirely by owners of flood-prone structures and property, particularly since one of the objectives of the insurance program is to eliminate federally-funded disaster relief in the event of flooding. Failure to continue the desirable lending institution and realtor policies concerning informing prospective purchasers of the flood vulnerability of riverine area land and structures will result in acquisition of flood-prone lands and structures by unwary buyers.

The failure of the individual communities to adopt utility policies in conformance with the floodland management element of the watershed plan may be expected to be interpreted as tacit public approval of urban development in flood-prone lands and in primary environmental corridors. If watershed communities with serious flood problems do not adopt emergency procedures to be invoked during such floods, the likely consequences are unnecessary damage to property as well as unnecessary risk to the safety and well-being of property owners.

Failure to implement the stream gaging recommendations contained with the plan will forego the opportunity to monitor the effects of future urbanization in the watershed and to ultimately refine the simulation modeling. If the miscellaneous measures recommended under the floodland management element for the Menomonee River Industrial Valley are not implemented, it is likely that high value industrial-commercial lands will be inundated during future floods that approximate the 100-year recurrence interval event, resulting in a temporary disruption of production and full-scale employment within that economically critical part of the watershed.

Water Quality Management Element

The principal negative effect of failure to implement the recommendations concerning abandonment of the four municipal sewage treatment plants within the watershed will be continuation of the large nutrient loads presently input to the main stem of the Menomonee River. If the recommended combined sewer overflow abatement measures are not implemented, the lower approximately five-mile-long reach of the Menomonee River will be subject to an average of about 50 combined sewer overflow occurrences per year and the resultant inorganic, organic, nutrient, pathogenic, and aesthetic pollution.

Failure to resolve the sanitary sewer flow relief device problem within the Menomonee River watershed will present localized public health hazards and objectionable instream aesthetic conditions. Similarly, failure to mitigate the discharge of industrial waste directly or indirectly to the surface water system within the watershed may result in localized pollution problems. If existing and new urban development are not provided with sanitary sewer service, localized and instream health hazards may be expected to continue and become aggravated within the watershed and localized objectionable aesthetic conditions also will continue. The likely consequence of not carrying out the recommended creosote pollution abatement measure for the Little Menomonee River is a continuation of the existing threat to the health of people and of aquatic flora and fauna. Failure to provide for control of runoff from animal feedlots and barnyards in the headwater portions of the watershed is likely to result in localized instream health hazards and objectionable aesthetic conditions. Watershedwide surface water quality degradation during and immediately after runoff events will continue if recommendations concerning land management measures for control of rural and urban diffuse source pollution are not implemented.

PUBLIC REACTION TO THE RECOMMENDED PLAN AND SUBSEQUENT ACTION OF THE MENOMONEE RIVER WATERSHED COMMITTEE

As an integral part of the watershed planning program three public informational meetings and a formal public hearing were held within the watershed upon the completion of a preliminary plan for the watershed.[2] The meetings and hearing were conducted by the Menomonee River Watershed Committee with the Chairman of the Watershed Committee presiding. The purpose of these meetings and hearing was to more fully inform public officials and interested citizens about the findings and recommendations of the watershed planning program and to obtain the reaction of public officials and interested citizens to the alternative plan elements considered and the preliminary comprehensive watershed plan recommended by the Commission staff and the Menomonee River Watershed Committee. The meetings and hearing were preceded by a program of notification, including news releases for publication in daily and weekly newspapers and circulation within the watershed and by distribution of a Commission Newsletter summarizing the planning program to about 2,200 interested individuals and organizations throughout the Region. In addition, a special presentation of the preliminary plan was made to a joint meeting of the Common Council of the City of Brookfield and Village Board of the Village of Elm Grove held on September 8, 1976.

A summary presentation of the inventory, analysis, and forecast findings; of the watershed development objectives; of the alternative land use and water control facility plans considered; of the recommended preliminary watershed plan; and of data on the cost and means for implementation of the recommended plan was made at each of the meetings and again at the hearing. The public informational meetings and the hearing were held in accordance with the schedule presented in Table 1, page 4 of this volume. Minutes of both the informational meetings and the public hearing were published by the Commission in October 1976[3] and transmitted to both the Menomonee River Watershed Committee and the Regional Planning Commission for review and consideration prior to final adoption of the recommended plan. The published minutes of the informational meetings and public hearing contain a detailed record of comments made by public officials, interested private citizens, and representatives of citizen groups on the preliminary plan. In addition, the minutes contain, as appendices, written comments and statements received from private citizens, representatives of citizen groups and the business community, and governmental bodies.

Approximately 240 persons attended the three general informational meetings and the public hearing. The published record of the proceedings of the meetings and hearing, including the written statements subsequently received by the Commission, indicates that the public reaction was generally quite favorable to the water pollution abatement and land use recommendations contained in the preliminary plan although some reservations were expressed about that aspect of the land use plan that recommends retention in essentially rural use of that portion of the City of Mequon lying within the watershed. In contrast to the favorable reaction to the water pollution abatement and land use plan elements, a sharp division of public opinion existed over the best course of action on some of the flood control recommendations. More specifically, controversy was evident over the following flood control recommendations:

- Resolution of the flood problems existing along the Menomonee River in the City of Wauwatosa between Harwood Avenue and N. 70th Street by structure removal and floodproofing. Some residents of flood-prone structures along this reach of the River opposed the structure floodproofing and removal recommended in the preliminary plan and advocated channelization—an alternative that was earlier considered by the Menomonee River Watershed Committee but rejected in favor of multipurpose structure floodproofing and removal which would not only abate flood damages but permit enlargement of Hart Park. In contrast, channelization of the Harwood Avenue-N. 70th Street reach of the Menomonee River was opposed by other residents of the City of Wauwatosa and by some aldermen on environmental and aesthetic grounds, while still other citizens favored structure removal.

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[2] *Prior to beginning the watershed planning program, a public hearing was held by the Watershed Committee on April 19, 1972, to elicit public opinions concerning the need for, objectives of, and scope and content of the proposed study. Testimony presented at that hearing was published by the Commission on May 1, 1972, as Minutes of the Initial Public Hearing-Menomonee River Watershed Study.*

[3] *Southeastern Wisconsin Regional Planning Commission, Minutes of Informational Meetings and Public Hearing—Comprehensive Plan for the Menomonee River Watershed, October 1976.*

- Resolution of the flood problems existing along the Menomonee River in the City of Wauwatosa between N. 70th Street and the eastern limits of the City. Some residents of the City of Wauwatosa and some aldermen opposed the major channelization recommended for this reach on environmental and aesthetic grounds and a request was made that a combination of less extensive channelization with low dikes and floodwalls be evaluated as a potentially effective and environmentally and aesthetically more acceptable solution to the flood problems of this reach. Owners of businesses on the north floodplain of this reach of the Menomonee River supported whatever structural measures would be required to prevent recurrence of costly flooding such as that experienced in April 1973. Importantly, the Common Council of the City of Wauwatosa adopted a resolution September 21, 1976, which stated in part "that the Metropolitan Sewerage Commission be and hereby is requested to dredge and deepen the channel of the Menomonee River and remove the debris in those areas where flooding presents a danger to citizens whose dwellings are located in the floodplain of Wauwatosa." Subsequent to that and on October 5, 1976, the Common Council of the City of Wauwatosa passed a resolution opposing any major channel improvements not only within the City but anywhere within the watershed. The John Muir Chapter of the Sierra Club and private citizens also expressed opposition to any further channelization in the watershed on ecologic and aesthetic grounds.
- Resolution of the flood problems existing along Underwood Creek in the Village of Elm Grove between W. North Avenue at the northern limits of the Village and the Waukesha-Milwaukee County line at the eastern limits of the Village. After the public hearing, the Village Board in an October 6, 1976, letter to the Regional Planning Commission indicated opposition to the intermediate and major channelization recommended for the entire length of Underwood Creek within the Village on the basis of the expected aesthetic and financial impacts.

In addition to the strong statements both supporting and opposing certain flood control recommendations contained in the preliminary watershed plan, the published record of the informational meetings and hearing indicated the need to stress in the final plan report the importance of channel cleaning and maintenance in order to alleviate minor flooding and drainage problems and the need to provide for some flexibility on that aspect of the land use plan element that recommends retention in essentially rural uses, particularly agricultural uses, within that portion of the City of Mequon contained within the Menomonee River watershed.

Each of the above aspects of the preliminary comprehensive plan for the Menomonee River watershed generated sharp differences of opinion or caused expressions of concern at the informational meetings and the public hearing and, therefore, was the subject of additional careful deliberation by the Menomonee River Watershed Committee subsequent to the informational meetings and hearing. The results of those deliberations are discussed below.

Reconsideration of Flood Control Recommendations for the Menomonee River Between Harwood Avenue in the City of Wauwatosa and N. 45th Street in the City of Milwaukee

Harwood Avenue-N. 70th Street Reach in the City of Wauwatosa: The published record of the informational meetings and public hearing indicates, as noted above, a sharp division of public opinion over the best course of action with respect to flood control along that reach of the Menomonee River bounded by Harwood Avenue on the upstream end and N. 70th Street on the downstream end. The public controversy over whether structure floodproofing and removal, as originally recommended in the preliminary watershed plan, or major channel modifications should be employed in this reach was complicated by the subsequent adoption of two resolutions by the Common Council of the City of Wauwatosa—also included in the published record of the informational meetings and public hearing. The first of these was intended to indicate support of channel cleaning and minor channel modification and the second indicated opposition to any major channel modifications, not only within the City but anywhere in the watershed.

The Menomonee River Watershed Committee carefully reviewed the alternatives considered under the planning program for abatement of the flood problems in the Harwood Avenue-N. 70th Street reach. In addition to the no-action alternative, three basic solutions—structure floodproofing and removal, major channel modifications, and dikes and floodwalls—were originally examined as possible means to resolve existing and forecast flood problems in this reach. After due consideration of the technical practicality and economic viability of each alternative and of certain important nontechnical and noneconomic factors, the Watershed Committee originally recommended that the structure floodproofing and removal alternative be incorporated in the preliminary watershed plan. More specifically, it was recommended that this be done in such a fashion so as to remove all structures from the 13 acre area bounded by the Hart Park on the west, W. State Street on the north, N. 70th Street on the east, and the Menomonee River on the south, thus not only eliminating flood damages in this area but providing for a needed expansion of Hart Park as proposed by local officials.

The second resolution by the City of Wauwatosa which indicated opposition to major channelization apparently was based primarily on aesthetic impact, which would also rule out the construction of dikes and floodwalls in this reach of the River. Therefore, the Watershed Committee reconfirmed its original recommendation to use structure floodproofing and removal as the principal means of resolving existing and forecast flood problems along the Menomonee River in the City of Wauwatosa in the reach bounded by Harwood Avenue on the upstream end and N. 70th Street on the downstream end and to provide for a needed expansion of Hart Park.

In recommending structure floodproofing and removal along the Harwood Avenue-N. 70th Street reach of the Menomonee River, it is recognized that there are two basic ways that this can be implemented, each of which was discussed in Chapter IV of this volume. The first or single purpose flood damage mitigation approach, as illustrated on Map 32, and assuming no channel modifications east of N. 70th Street, would involve the floodproofing of all flood-prone commercial structures regardless of flood stage, the floodproofing of residential structures for which the 100-year recurrence interval flood stage under year 2000 plan land use is below the first floor elevation, and the removal of those residential structures for which the design flood stages at or above the first floor elevation. Under the first approach, a total of up to 116 structures—99 residential buildings and 17 commercial buildings—would be floodproofed in the Harwood Avenue-N. 70th Street reach, and a total of up to 41 residential structures would be removed. Of the 116 structures that may require floodproofing under this approach, 20 are located in the area bounded on the west by Hart Park, on the north by State Street, on the east by N. 70th Street, and on the south by the Menomonee River, while the remaining 96 structures include park buildings in Hart Park and structures located north of State Street or south of the Menomonee River. Of the 41 residential structures which may require removal under this alternative, 29 are located in the aforementioned area east of Hart Park and the remaining 12 are located north of W. State Street. The capital cost of the first approach to structure floodproofing and removal is estimated at $1,975,800—$152,100 for structure floodproofing and $1,823,700 for structure removal—and the equivalent average annual cost, assuming an interest rate of 6 percent and a project life and amortization period of 50 years, is $125,400.

The above structure floodproofing and removal alternative for the Harwood Avenue-N. 70th Street reach of the Menomonee River in the City of Wauwatosa assumes that major channelization, as originally recommended in the watershed plan, would not be implemented. With major channelization downstream of N. 70th Street, a reduction in flood stages may be expected in the flood-prone areas immediately upstream of N. 70th Street because of the drawdown produced by the reduction in stage expected downstream of N. 70th Street. As a result of the reduction in stage upstream of N. 70th Street, the expected number of structures requiring floodproofing or removal would be reduced slightly, as would the corresponding cost. More specifically, a total of 113 structures—96 residential buildings and 17 commercial buildings—may require floodproofing in the Harwood Avenue-N. 70th Street reach under the single-purpose flood damage mitigation approach assuming channelization downstream of N. 70th Street, and a total of up to 41 residential structures may require removal. Of the 113 structures which may require floodproofing, 20 would be located in the area bounded on the west by Hart Park, on the north by W. State Street, on the east by N. 70th Street, and on the south by the Menomonee River, whereas the remaining 93 structures include park buildings in Hart Park and structures located north of W. State Street and structures south of the Menomonee River. Of the 41 residential structures that may require removal under this subalternative, 29 would be located in the aforementioned area east of Hart Park and the remaining 12 would be located north of W. State Street. The capital cost of this approach to structure floodproofing and removal is estimated at $1,941,600—$117,900 for structure floodproofing and $1,823,700 for structure removal—and the equivalent average annual cost, assuming an interest rate of 6 percent and a project life and amortization period of 50 years is $123,200.

The second multiple purpose approach, as shown on Map 35, would be identical to the first or single purpose approach except that all structures—regardless of structure type and the relationship between the design flood stage and the first floor elevation—that are located within the area bounded by Hart Park on the west, W. State Street on the north, N. 70th Street on the east, and the Menomonee River on the south, would be removed primarily to permit the expansion of Hart Park. The second approach to structure floodproofing and removal is multiple purpose in that it would mitigate flood damages and facilitate park expansion. Under the multiple purpose approach, a total of up to 93 structures—76 residential buildings and 17 commercial buildings—would be floodproofed in the Harwood Avenue-N. 70th Street reach and a total of 61 residential structures would be removed. The 93 structures which may require floodproofing include park buildings in Hart Park and structures located north of W. State Street and structures south of the Menomonee River. Of the total of 61 residential structures which would require removal under this approach, 49 would be located in the aforementioned area east of Hart Park and the remaining 12 would be located north of W. State Street. The capital cost of the second approach to structure floodproofing and removal is $2,703,200—$100,200 for structure floodproofing and $2,603,000 for structure removal—and the equivalent annual cost is estimated at $171,500.

The average annual flood abatement benefits that would be achieved in this reach, assuming major channelization downstream of N. 70th Street, are estimated at $71,700 for either of the two approaches and, therefore, for the single purpose approach the average annual costs would exceed average annual benefits by $51,500 for a benefit-cost ratio of 0.58, whereas for the multiple purpose approach average annual costs would exceed average annual benefits by $99,800 for a benefit-cost of 0.42. It should be noted, however, that the latter benefit-cost ratio is based solely on the direct costs and benefits associated with flood damage abatement and does not include any benefits attendant to the provision of an expanded park used for intensive recreational activities, nor any benefits attendant to the urban development entailed.

While the choice between these two approaches to structure floodproofing and removal in the Harwood Avenue-N. 70th Street reach is ultimately a matter to be decided by the City of Wauwatosa, the Menomonee River Watershed Committee recommended that the second, or multiple purpose, approach be taken. As discussed in Chapter IV of this volume, this recommendation was originally based, in part, on the indicated need for the expansion of Hart Park and concern over the long-term condition of the older housing stock in this area and the continued stability and viability of the neighborhood. The need to expand Hart Park and the need to retain the larger residential areas in the vicinity of the park as viable neighborhoods over time are more likely to be met by a multipurpose approach involving the enlargement of the park and serving recreation and urban redevelopment as well as flood control purposes than by a single purpose flood control approach.

If the single purpose approach to floodproofing and removal is in fact implemented by the City of Wauwatosa, the result is likely to be an irregular, scattered pattern of remaining structures and vacant lots. This is less apt to contribute to the stability and viability of the residential neighborhood than the enlargement of the park and would raise the problem of responsibility for maintenance and use of the scattered parcels of vacant lands resulting from the structure removal. Although it may be possible to fill some of the cleared lots and to build new housing units with first floor elevations above the design flood stage, this is not likely to be technically and economically feasible in all cases.

Channelization-Dike and Floodwall Subalternative Along the Menomonee River Downstream of N. 70th Street in the City of Wauwatosa: In response to the recommendation contained in the preliminary plan that channelization be used to resolve flood problems along the Menomonee River in the City of Wauwatosa between N. 70th Street and the eastern limits of the City, it was suggested at one of the informational meetings and at the public hearing that a subalternative be developed that would consist of replacing the channelization component of the recommended measure by a combination of less extensive channelization supplemented with low dikes and floodwalls. Subsequent to the informational meetings and the public hearing, and at the request of the Menomonee River Watershed Committee, the Commission staff conducted a technical, economic, and environmental evaluation of the suggested subalternative with the results described below.

As described in some detail in Chapter IV of this volume, the Watershed Committee originally recommended for inclusion in the preliminary watershed plan major channelization beginning immediately east of the N. 70th Street bridge and extending downstream 1.22 miles to a point in the City of Milwaukee 0.25 mile downstream of N. Hawley Road. This channelization was viewed as the solution to existing and probable future flood problems in the City of Wauwatosa along the reach of the Menomonee River bounded by Harwood Avenue at the upstream end and the eastern limits of the City at the downstream end.

The channelization-dike and floodwall subalternative suggested at the public informational meeting and hearing was intended as a possible replacement for the channelization component of the recommended channelization-structure floodproofing and removal measures. The principal objective of the suggested subalternative was to reduce the potentially adverse aesthetic impact of the channelization component of the recommended alternative which would require extensive cross-section enlargement and placement of a concrete invert and sidewalls. Most of the trees and shrubs lining both sides of existing channel would probably have to be removed in order to construct the originally recommended channel works. The resulting aesthetic impact would be particularly severe along that reach of the Menomonee River downstream of N. 70th Street. This reach is lined by a thick, but narrow, band of trees and shrubs, most of which would have to be removed to accomplish the channel improvement. The aesthetic impact would be apparent to residents of the adjacent areas as well as to users of the County parkway and parkway drive. Although construction of the recommended channel works downstream of N. 70th Street in the City of Wauwatosa would be immediately followed by landscaping consisting of placement of turf, shrubs, and trees, the density, size, and overall appearance of the replacement vegetation would not be similar to that of the existing vegetation, especially in the years immediately following construction of the project.

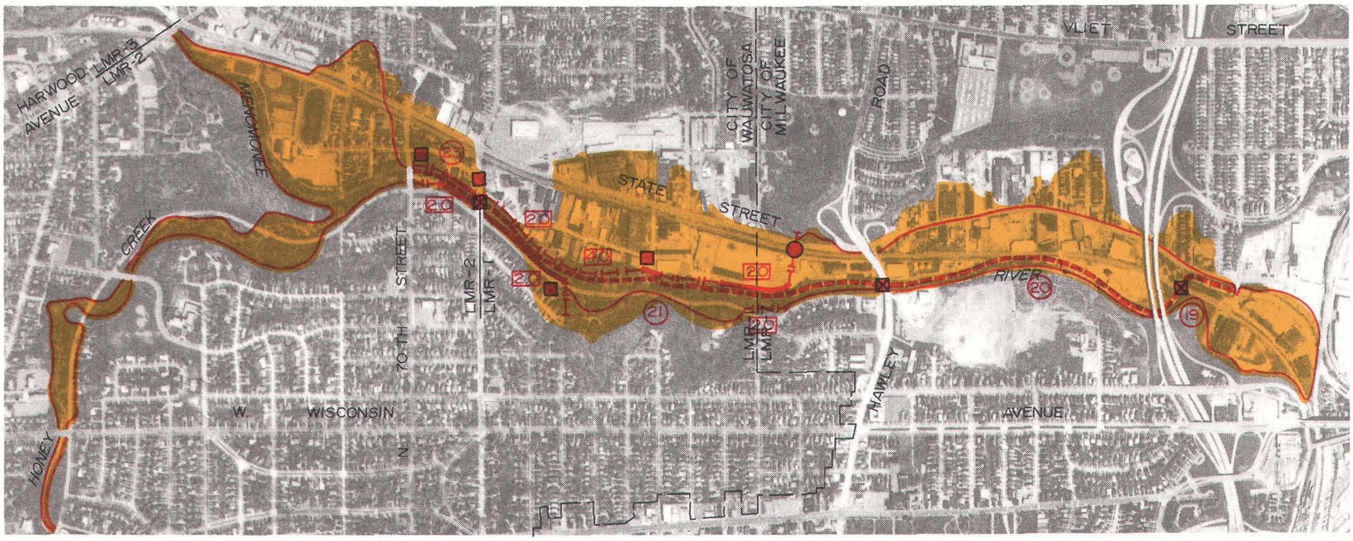
The basic premise of using a combination of channel improvements and dikes and floodwalls is that the dikes and floodwalls would serve to confine the flood flows in the riverine areas, facilitating a reduction in the degree of channel modification required thus permitting retention to a greater degree of the existing topography and shrub and tree growth in the area affected. More specifically, the use of supplemental dikes and floodwalls was presumed to permit restricting channel modifications to the existing channel area with no disturbance—other than placement of dikes and floodwalls—to the adjacent floodplain.

Physical Features and Economic Analysis: In accordance with the suggestion made at the public informational meeting and hearing, a channel-dike and floodwall combination was designed and sized so as to pass the peak 100-year recurrence interval flood discharges under the year 2000 land use plan conditions with two-foot freeboard below the top of the dikes and floodwalls. The channelization-dike and floodwall subalternative is shown on Map 53. Representative channel floodplain cross-sections at River Mile 5.75—about 0.35 mile east of the N. 70th Street bridge—are shown on Figure 48 for the following three conditions: the existing channel and floodplain; the channelization component of the channelization-structure floodproofing and removal alternative originally recommended prior to the public information meeting and hearing; and the suggested channelization-dike and floodwall subalternative.

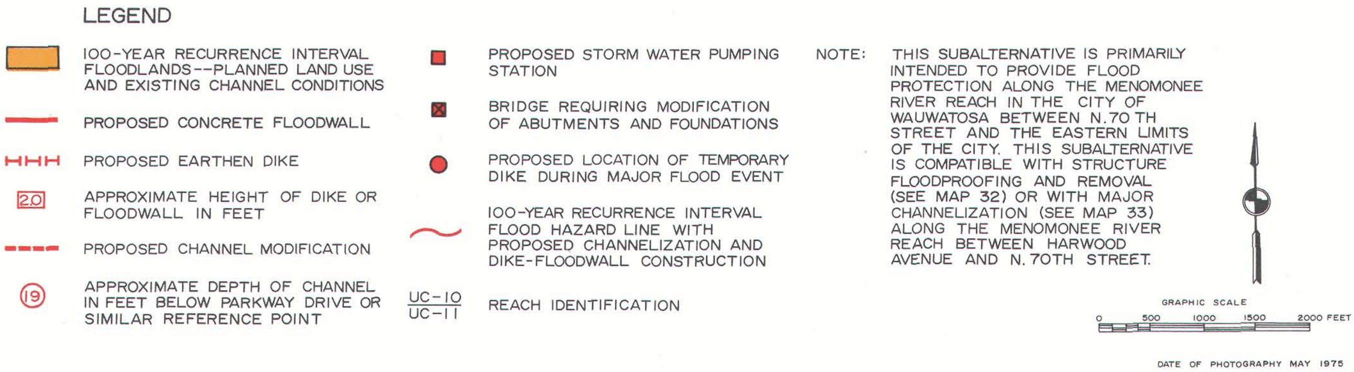
Under the channelization-dike and floodwall subalternative, the major channel improvements would consist of a rectangular concrete channel having a width approxi-

Map 53

CHANNELIZATION-DIKE AND FLOODWALL SUBALTERNATIVE ALONG THE MENOMONEE RIVER IN THE CITY OF WAUWATOSA



LEGEND



In response to suggestions made at the informational meetings and the public hearing, a channelization-dike and floodwall system was developed as another potential means of providing flood protection to residential and commercial structures located along the Menomonee River in the City of Wauwatosa downstream of N. 70th Street. The primary objective of the evaluation of this additional measure was to explore the possibility of reducing the potentially adverse aesthetic impact of the major channelization originally recommended for this reach. The basic premise of considering channel improvements supplemented with earthen dikes and concrete floodwalls is that the dikes and floodwalls would permit restricting channel modifications to the existing channel area with little or no disturbance—other than placement of dikes and floodwalls—to the adjacent floodplain. The channelization-dike and floodwall subalternative was found to be technically practicable, economically feasible and, relative to the original channelization recommendation, could be expected to have a less undesirable aesthetic impact. Accordingly, the comprehensive watershed plan as originally presented for public review and comment was revised so as to recommend a combination of channelization and dikes and floodwalls along the Menomonee River downstream of N. 70th Street in the City of Wauwatosa.

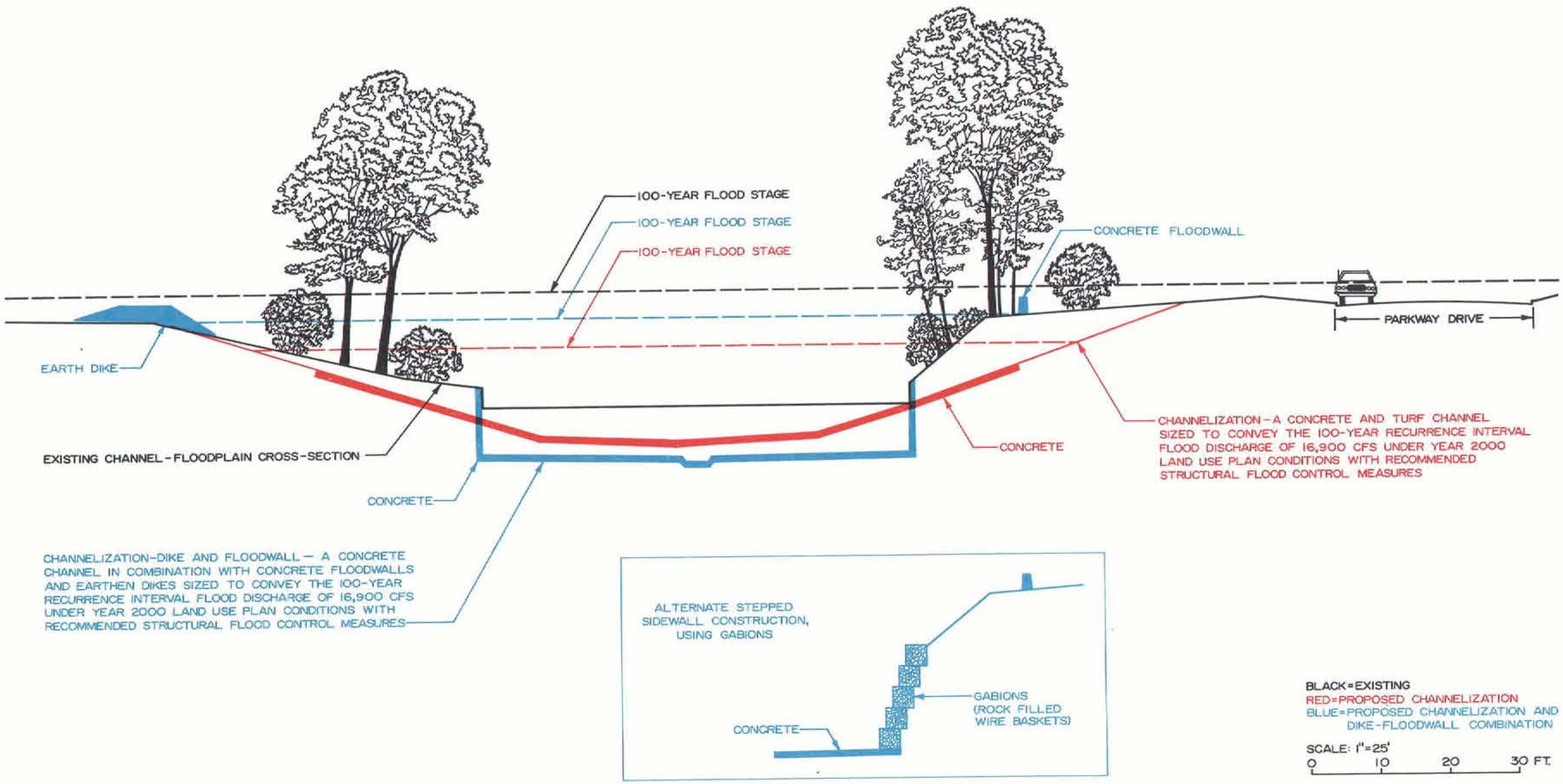
Source: SEWRPC.

mately equal to the existing bank-to-bank width of the Menomonee River in this reach, and a depth sufficient to convey the 100-year recurrence interval discharge under year 2000 plan land use conditions with upstream structural flood control measures within the confines of dikes and floodwalls having a maximum height of about four feet above existing ground grade. The maximum height restriction on the dikes and floodwalls was established on the basis of aesthetic considerations to assure that the dike and floodwall structures would not constitute a major obstruction to the view of the riverine area from the parkway and parkway drive.

Under the subalternative, major channel improvements would be carried out over a total reach of 1.65 miles extending from the N. 70th Street crossing of the Meno-

Figure 48

CROSS SECTIONS CORRESPONDING TO EXISTING TOPOGRAPHIC CONDITIONS, MAJOR CHANNELIZATION, AND A CHANNELIZATION-DIKE AND FLOODWALL COMBINATION AT RIVER MILE 5.75 ON THE MENOMONEE RIVER IN THE CITY OF WAUWATOSA



Source: SEWRPC.

monee River in the City of Wauwatosa to the N. 45th Street crossing of the Menomonee River in the City of Milwaukee. The latter location also defines the upstream termination of existing major channel works along the lower portions of the Menomonee River in the City of Milwaukee. Under the channelization-dike and floodwall subalternative, the 1.65 mile length of channelization exceeds by 0.43 mile the 1.22 mile length of channel modification that would be required under the previously recommended channelization-structure floodproofing and removal alternatives. The increased length is necessitated by the significantly lower channel bottom grade required, as shown on Figure 48, to convey flood-flows at the desired maximum stages within the confines of the dikes and floodwalls.

The channelization would lower the existing Menomonee River channel grade by about seven feet at the downstream side of the N. 70th Street (River Mile 6.10) crossing of the River. The lowering of the channel bottom at this location would be accomplished through construction of a drop structure, thus retaining the existing channel bottom profile through and upstream of the N. 70th Street bridge. Under the channelization-dike and floodwall subalternative, the channel bottom immediately downstream of the N. 70th Street bridge would be about 3.5 feet deeper than the channel bottom grade at that location under the originally recommended channelization-structure floodproofing and removal alternative. The channelization required for the channelization-dike and floodwall subalternative would lower the existing Menomonee River channel grade by about seven feet at the site of the former pedestrian bridge over the Menomonee River (River Mile 5.66), or about three feet below the channel bottom grade under the channelization-structure floodproofing and removal alternative. The channelization would lower the existing Menomonee River channel grade by about six feet at the N. Hawley Road crossing of the Menomonee River (River Mile 5.15), or about three feet below the channel grade under the channelization-structure floodproofing and removal alternative. The channelization would lower the existing Menomonee River channel grade by about 2.5 feet at the Stadium Freeway (USH 41) crossing of the Menomonee River (River Mile 4.63). As noted above, the channel structure itself would be in the general form of an open concrete box having a width of approximately 50 to 70 feet with the vertical side walls ranging in depth from about 9 to 12 feet throughout the project reach.

Under this subalternative, a total of 1.23 miles of earthen dikes and concrete or sheet steel floodwall would be constructed along portions of both sides of the Menomonee River reach between N. 70th Street and N. 60th Street extended. About 0.80 mile of earthen dike and about 0.43 mile of concrete or sheet steel floodwalls would be required. At locations where the dike or floodwall structure crosses roadways, such as the Menomonee River Parkway Drive, the roadway grade would have to be elevated to the crest elevation of the dike or floodwall structure, thereby, in effect, becoming a part of the structure; or a gate or bulkhead would have to be provided for insertion across the roadway during the flood event. As shown on Map 53, the N. 68th Street bridge is included within the reach along which dikes and floodwalls would be constructed. It may be necessary, under this subalternative, to construct sidewalls along the railings on this bridge so as to prevent floodwaters from flowing onto and along 68th Street.

This subalternative would have to include provision for the construction of a minimum of four major storm water lift or pumping stations and backwater gates near the ends of storm sewer outfalls that are tributary to the Menomonee River. These facilities would be required to prevent the movement of floodwaters from the River into the surrounding urban area via these storm water drainage ways and to prevent accumulation of lateral runoff behind the dikes and floodwalls, thereby creating local drainage problems. It was assumed that all river crossings in the 1.65-mile-long channelized reach could be retained with some reconstruction of their abutments and foundations.

The implementation of the channelization-dike and floodwall subalternative, particularly the significant lowering of the bottom of the Menomonee River channel through the N. 70th Street-N. 45th Street reach, would require reconstruction of certain public utilities that pass beneath the Menomonee River. For example, a City of Wauwatosa sanitary sewer and a water main and a Milwaukee-Metropolitan Sewerage Commission trunk sewer pass beneath the Menomonee River at N. 68th Street while a Sewerage Commission trunk sewer passes beneath the Menomonee River at N. 60th Street extended. Although costs for reconstruction of these crossings are not explicitly included in the estimated project cost, such costs are provided for in the 25 percent contingency added to construction cost estimates.

Utilizing an annual interest rate of 6 percent and project life and amortization period of 50 years, the average annual cost of the suggested subalternative is estimated at $186,700 consisting of the following: amortization of the $2,230,000 capital cost of the channel modification, amortization of the $110,000 capital cost of dike construction, amortization of the $260,000 capital cost of floodwall construction, amortization of the $260,000 capital cost of four storm water pumping stations, and $5,200 annual operation and maintenance costs. The $186,700 equivalent average annual cost of the channelization-dike and floodwall subalternative is thus somewhat less than the $209,700 equivalent average annual cost of the channelization component of the originally recommended channelization-structure floodproofing and removal measure for the same reach.

The above estimated construction costs for the channel modification component of this subalternative include a 10 percent increment to account for the anticipated added cost of restricting all construction activities to the area between the existing channel banks so as to minimize disturbance of the topographic conditions and vegetation in the parkway immediately adjacent to and lying on both sides of the channel. This 10 percent increase in capital cost is in addition to the 25 percent contingency added to all construction cost estimates and the 10 percent increment that is provided to account for engineering and administrative costs. The average annual flood abatement benefit in this reach is estimated at about $331,000, thus yielding a benefit-cost ratio of 1.77 for the suggested channelization-dike and floodwall subalternative, and 1.58 for the channelization component of the originally recommended channelization-structure floodproofing and removal measure.

It is important to note that the above benefit-cost analysis assumes that all the costs of the structural works would be assigned to the flood abatement benefits that would be achieved along the Menomonee River in the City of Wauwatosa between N. 70th Street and the eastern limits of the City. In the case of the channelization-dike and floodwall subalternative, and as discussed in a subsequent section, extension of the deepened channel downstream into the City of Milwaukee would also substantially reduce flood damages in and along the Menomonee River in the City of Milwaukee between Hawley Road and N. 45th Street. Therefore, in order to identify the most economic combination of structural flood abatement measures for the Menomonee River between N. 70th Street and N. 45th Street, it is necessary to examine the sum of all the costs and all the benefits for each of the two available measures.

Nontechnical and Noneconomic Considerations: A decision as to which of these two flood control measures would be most appropriately applied to that reach of the Menomonee River downstream of N. 70th Street in the City of Wauwatosa must be based in part on certain nontechnical and noneconomic considerations. More specifically, the aesthetic advantage of the channelization-dike and floodwall subalternative achieved by minimal disturbance to floodplain topography and vegetation must be weighed against the potential danger inherent in the large and deep concrete box structure required for the channelization-dike and floodwall subalternative.

The channelization-dike and floodwall subalternative has the advantage, as illustrated in Figure 48, of causing less disruption to the topography adjacent to the stream and to the trees and other vegetation that currently exist in that area. Although the attractivensss of the existing natural channel and floodplain would be compromised by the presence of dikes and floodwalls and by the open concrete box structure needed in the channel portion of the cross-section, the degree of disturbance would not be so great as with construction of a concrete trapezoidal channel without the dikes and floodwalls. Although the channelization-dike and floodwall subalternative offers some aesthetic advantages in preservation of existing vegetation in the area adjacent to the channel, the presence of the deep—up to 12 feet—concrete box structure in the channel itself would also detract from the appearance of the riverine area. In addition, under average streamflow conditions, the water surface would be as much as 11 feet below the top of the banks as defined by the top of the concrete channel sidewalls. Thus, the high vertical sidewalls of the open box structure would constitute a safety hazard particularly to young children who are normally drawn to waterways. This safety hazard could be reduced by using a stepped sidewall construction in place of the vertical sidewalls, as illustrated in Figure 48. Gabions could be used for the stepped sidewall construction thereby not only providing a safety feature but at the same time helping to offset the adverse aesthetic impact of the stark, vertical concrete sidewalls. Gabions are rock-filled wire baskets commonly used to provide river bank or lake shore erosion protection and stabilization. Figure 49 shows gabions that have been installed along a short reach of Honey Creek in the City of Wauwatosa about 0.4 mile upstream of the confluence with the Menomonee River. Inasmuch as the wire that forms the containment baskets is not readily seen because of the rocks contained within the baskets, a gabion installation has a more "natural" appearance then does a concrete channel sidewall. In time natural vegetative growth is established between the rocks adding to the "natural" appearance of the installation.

It is important to note, however, that gabions offer more resistance to flow than does the smoothly-finished concrete normally used to construct major channel modifications. The higher flow resistance of gabions relative to concrete is illustrated by the fact that the former has a Manning roughness coefficient that is approximately twice that of the latter. Therefore, for a given design flood flow, a channelized cross-section incorporating gabion sidewalls and a concrete bottom would have to have a somewhat larger cross-sectional area than if concrete is used for both the sidewalls and the bottom.

Use of a stepped sidewall, with or without gabions, could result in more disturbance of the natural topography and vegetation along the channel than would occur if vertical sidewalls were used. This disadvantage of stepped sidewalls could be offset by moving the channel sidewalls inward and deepening the channel to provide compensating conveyance. The use of stepped sidewalls constructed of gabions with the top of the sidewalls coincident with the top of the existing banks would, because of a combination of a reduction in channel width and increased flow resistance, require the channel bottom to be up to three feet lower along the Menomonee River between N. 70th and N. 45th Steets than would be required if a concrete box channel section were used.

The ultimate decision of whether to use vertical concrete sidewalls, stepped concrete sidewalls, or stepped gabion sidewalls would probably be made primarily on the basis of safety and aesthetic considerations as opposed to cost factors. Use of any three of the above sidewall treatment measures would not significantly affect the total construction cost of the channelization-dike and floodwall subalternative.

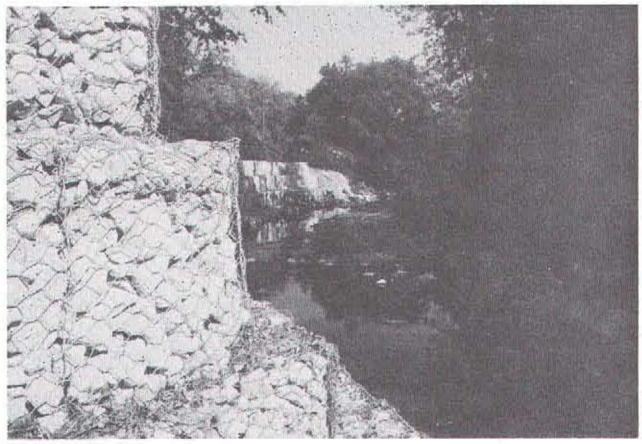
Implications for the Structure Floodproofing Recommendations Along the Menomonee River in the City of Milwaukee Between N. 60th Street Extended and N. 45th Street: As described in Chapter IV of this volume, development along the north bank of the 0.93-mile-long portion of the Menomonee River bounded at the upstream end by N. 60th Street Extended (River Mile 5.38) and at

Figure 49

GABION INSTALLATION ALONG THE NORTH BANK OF HONEY CREEK AT APPROXIMATELY RIVER MILE 0.4 IN THE CITY OF WAUWATOSA

Overall Installation Looking Downstream (East)

Upstream End Showing Wire Baskets Filled With Rocks



Source: SEWRPC.

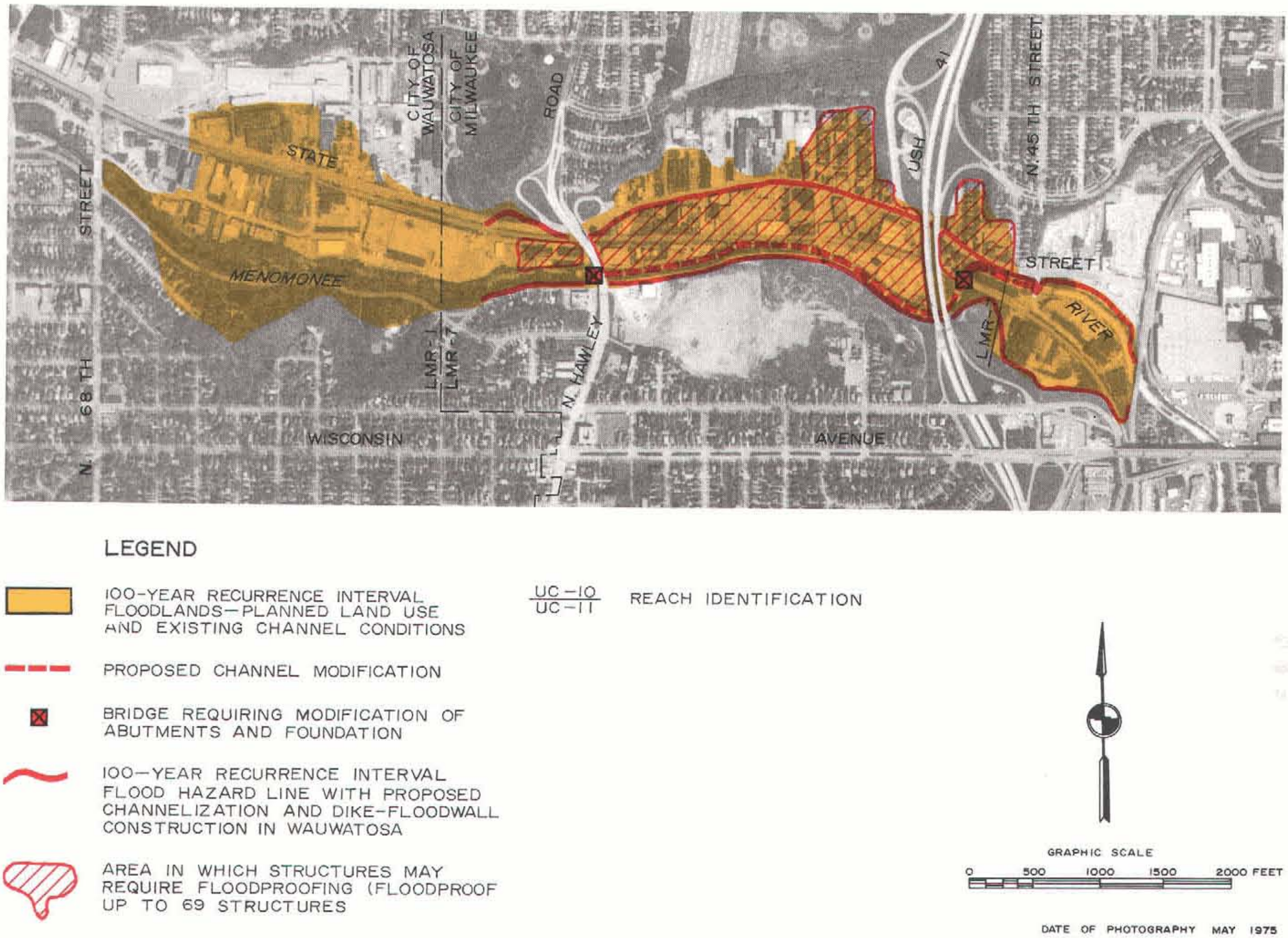
the downstream end by N. 45th Street (River Mile 4.45) in the City of Milwaukee is flood damage-prone. The average annual monetary flood risks under year 2000 plan land use conditions for this reach are estimated at $48,600. In addition to the no-action alternative, four alternative solutions—structure floodproofing, a dike-floodwall system, major channelization, and bridge alteration or replacement—were originally examined as possible means to resolve the existing and forecast flood problem in this reach. Based on that analysis, it was recommended that flood damage relief be achieved by floodproofing up to 77 commercial, industrial, and residential structures at a capital cost of $320,200. The average annual cost of such floodproofing at an annual interest rate of 6 percent and a project life and amortization period of 50 years is $20,300 which, compared to the average annual damages of $48,600, yields a benefit-cost ratio of 2.39 and an excess of annual benefits over annual costs of about $28,300.

Hydraulic and economic analyses indicate that implementation of channelization-dike and floodwall subalternative along the Menomonee River in the City of Wauwatosa would, because of the resulting lower channel grade extending downstream into the City of Milwaukee as far east as N. 45th Street, yield a substantial reduction in flood damages along the 0.93-mile-long reach of the Menomonee River in the City of Milwaukee. Under conditions of the channel extension, the average annual flood damages in the City of Milwaukee reach would be reduced by 73 percent, from about $48,600 to $13,300. Correspondingly, the extent and cost of necessary floodproofing measures to provide flood relief in that reach would be reduced from the originally recommended floodproofing of up to 77 structures at a capital cost of $320,200 and an equivalent average annual cost of $20,300, to the floodproofing of up to 69 structures—53 residential and 16 commercial-industrial—as shown on Map 54 at a capital cost of $83,600 and an equivalent average annual cost of $5,300. Therefore, assuming construction of the channelization-dike and floodwall subalternative in the City of Wauwatosa, which would of necessity extend downstream through the flood-prone reach in the City of Milwaukee, the originally recommended structure floodproofing measures for the City of Milwaukee flood-prone reach could be carried out as an economic supplemental project at an average annual additional cost of $5,300, yielding an average annual benefit of $13,300 for a benefit-cost ratio of 2.51 and an excess of annual benefits over costs of about $8,000.

In order to correctly identify the most economic combination of structural flood abatement measures for the entire 1.65-mile-long Menomonee River reach in the Cities of Wauwatosa and Milwaukee bounded at the upstream end by N. 70th Street and at the downstream end by N. 45th Street, it is necessary to examine the sum of all the costs and all the benefits for the two available measures. Prior to the analysis of the channelization-dike and floodwall subalternative, the watershed plan recommended that major channelization be used to resolve flood problems in the Wauwatosa portion of this reach and that structure floodproofing be applied in the Milwaukee portion of this reach. The capital cost and the average annual cost of the channelization are estimated at $3,296,200 and $209,700, respectively, and the capital cost and the average annual cost of the structure floodproofing is estimated at $320,200 and $20,300, respectively for a total capital cost of $3,616,400 and a total average annual cost of $230,000. The average annual

Map 54

STRUCTURE FLOODPROOFING ALONG THE MENOMONEE RIVER IN THE CITY OF MILWAUKEE
ASSUMING THE CHANNELIZATION-DIKE AND FLOODWALL SUBALTERNATIVE IN THE CITY OF WAUWATOSA



Implementation of the channelization-dike and floodwall subalternative along the Menomonee River downstream of N. 70th Street in the City of Wauwatosa would, because of the resulting lower channel grade extending downstream into the City of Milwaukee as far east as N. 45th Street, yield a reduction in flood damages along the 0.93-mile-long reach of the Menomonee River in the City of Milwaukee. Accordingly, the extent of structure floodproofing originally recommended for the N. 60th Street Extended-N. 45th Street reach of the Menomonee River in the City of IMilwaukee would be reduced somewhat. More specifically, and as shown above, the necessary floodproofing measures would be reduced from the originally recommended floodproofing of up to 77 structures to the floodproofing of up to 69 structures—53 residential and 16 commercial.

Source: SEWRPC.

flood abatement benefit in the Wauwatosa portion of this reach is estimated at $259,200 and in the Milwaukee portion of this reach is estimated at $48,600, for a total average annual flood abatement benefit of $307,800, yielding a benefit-cost ratio of 1.34 and an excess of annual benefits over costs of about $77,800.

Assuming that the existing and forecast flood problems in the N. 70th Street-N. 45th Street reach are essentially eliminated by a combination of channelization and dikes and floodwalls directed at the Wauwatosa flood problems and a combination of channelization and structure floodproofing directed at the Milwaukee flood problem, the total capital and average annual costs are estimated at $3,180,000 and $207,000, respectively, as described above and the total average annual benefits are $307,800. Therefore, this alternative has a benefit-cost ratio of 1.49 and an excess of annual benefits over costs of about $100,800.

Consequently, the channelization-dike and floodwall-structure floodproofing combination is a somewhat more economic means of flood damage mitigation along the N. 70th Street-N. 45th Street reach of the Menomonee River than is the originally recommended channelization-structure floodproofing combination. The $207,000 average annual cost of the former is 10 percent less than the $230,000 average annual cost of the latter; the average annual benefits are the same for both approaches; and the benefit-cost ratio of the former is 1.49 compared to 1.34 for the latter.

Action of the Menomonee River Watershed Committee: After reviewing the technical, economic, and nontechnical and noneconomic features of the channelization-dike and floodwall subalternative for the Menomonee River downstream of N. 70th Street in the City of Wauwatosa and the previously recommended channelization-structure floodproofing and removal alternative for this reach, the Menomonee River Watershed Committee determined that the former alternative should be included in the final watershed plan. The channelization-dike and floodwall subalternative was determined to be preferable to the approach employing only channelization for two principal reasons. First, the channelization-dike and floodwall subalternative would have less undesirable impact on the aesthetic character of the riverine environment since it would minimize disturbance to the existing topography and vegetation in the area adjacent to the existing channel. Second, the channelization-dike and floodwall subalternative, in combination with structure floodproofing on the north floodplain of the Menomonee River between N. 60th Street Extended and N. 45th Street in the City of Milwaukee, would provide, of all the alternatives examined, the most economical solution to the flood problems that exist along the Menomonee River between N. 70th Street in the City of Wauwatosa and N. 45th Street in the City of Milwaukee. Therefore, the Menomonee River Watershed Committee recommended that the channelization-dike and floodwall subalternative be used to resolve the flood problems along the Menomonee River in the City of Wauwatosa downstream of N. 70th Street and that this measure, supplemented with structure floodproofing, be used to resolve the flood problems along the Menomonee River in the City of Milwaukee between N. 60th Street Extended and N. 45th Street.

Reconsideration of Flood Control Recommendations Along Underwood Creek in the Village of Elm Grove

As noted above and as documented in the published proceedings of the informational meetings and the public hearing on the preliminary watershed plan, the Village of Elm Grove because of aesthetic and financial considerations formally indicated opposition to any form of channelization along Underwood Creek within the Village. Therefore, subsequent to the informational meetings and public hearing and at the request of the Menomonee River Watershed Committee, an evaluation was conducted of an additional alternative means of mitigating existing and probable future flood problems along Underwood Creek within the Village of Elm Grove.

The entire 2.25-mile-long length of Underwood Creek within the Village of Elm Grove, extending from W. North Avenue at the upstream end to the Waukesha-Milwaukee County line at the downstream end, is flood-prone and incurred heavy flood damage during the April 1973 flood event. Average annual monetary flood risks to commercial and residential property along Underwood Creek within the Village of Elm Grove under year 2000 plan land use are estimated at $362,800. In addition to the no-action alternative, and as described in Chapter IV of this volume, eight alternative solutions were originally evaluated as possible means to resolve existing and forecast flood problems in this reach. These alternative solutions were detention storage, structure floodproofing and removal, major channel modification, minor channel modification, dikes and floodwalls, bridge and culvert alteration or replacement, a channelization-storage composite, and a storage-major channelization-intermediate channelization-floodproofing composite. Based on that evaluation, it was originally recommended that flood damage relief be achieved by the following combination of measures: development of a 215 acre-foot detention reservoir upstream of the Village on Dousman Ditch in the City of Brookfield; construction of 1.14 miles of intermediate channelization along the Underwood Creek reach bounded by W. North Avenue on the upstream end and Juneau Boulevard on the downstream end; construction of 0.91 mile of major channelization along the Underwood Creek reach bounded at the upstream end by Juneau Boulevard and at the downstream end by the Waukesha-Milwaukee County line; and floodproofing of up to 105 residential structures.

The estimated capital cost of this recommendation was $3,272,000 and the equivalent average annual cost, utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, was estimated at $214,200. The recommended primarily structural solution to existing and forecast flood problems thus had a benefit-cost ratio of 1.69 and an excess of annual benefits over annual costs of about $148,600.

Detention Storage-Structure Floodproofing and Removal Alternative: Channelization, which is opposed by Village officials, was a major component of the originally recommended flood control measure for the Village of Elm Grove. Accordingly, the Watershed Committee reviewed the various primarily structural flood control alternatives previously considered for mitigation of Underwood Creek flood problems in order to identify a means of resolving or significantly reducing the flood problem while at the same time avoiding the use of channel modifications or any other similar aesthetically unacceptable and costly approaches.

Based on this review, it was concluded that any additional flood control alternative should include the 215 acre-foot detention reservoir for two reasons. First, that reservoir is an integral part of the floodland management recommendations for flood-prone areas along Underwood Creek upstream of the Village of Elm Grove in the City of Brookfield, and the proposed reservoir was well received at the public informational meetings and public hearing. Second, the detention reservoir is very cost effective in that development of the upstream detention storage in the absence of any other floodland management measures would result, as described in detail in Chapter IV of this volume, in a 44 percent reduction in average annual flood damages along Underwood Creek within the Village of Elm Grove and would accomplish this at a benefit-cost ratio of 4.24. It was further concluded that, in order to provide the opportunity to eliminate most of the flood problems along Underwood Creek in the Village of Elm Grove, structure floodproofing and removal was the only technically feasible means of supplementing detention storage without incurring aesthetic objections associated with intermediate or major channel modifications or with dikes and floodwalls. Therefore, the Watershed Committee conducted a technical, economic, and environmental evaluation of a tenth floodland management alternative for the Village of Elm Grove consisting of a 215 acre-foot detention reservoir on Dousman Ditch in the City of Brookfield supplemented with structure floodproofing and removal.

The 100-year recurrence interval event under year 2000 plan land use conditions was used as the basis for determining how many flood-prone structures would have to be removed and the number that would have to be floodproofed. In the case of residential structures in the primary flooding zone, floodproofing was assumed to be feasible if the design flood stage was below the first floor elevation, and structure removal was assumed to be required if the design flood stage was at or above the first floor elevation. Floodproofing was assumed to be feasible for all nonresidential structures within the primary flooding zone irrespective of flood stage. For structures located in the secondary flooding zone, that is, outside of but immediately adjacent to the 100-year recurrence interval floodland, it was assumed that floodproofing may be required for those structures with basement floors below the elevation of the design flood stage. As shown on Map 55, the analysis indicated that one residential structure may have to be removed from the 100-year recurrence interval floodlands under this alternative and a total of up to 187 structures located in the primary and secondary flooding zones—164 residential and 23 commercial and other structures—may require some form of floodproofing. Future flood damage to private residences and commercial structures within the Village of Elm Grove would be virtually eliminated by the floodproofing and removal measures in combination with the upstream detention storage.

Utilizing an annual interest rate of 6 percent and a project life and amortization period of 50 years, the equivalent average annual cost of this alternative is estimated at about $74,700 consisting of: $31,800 per year for amortization of the $501,000 capital cost of structure floodproofing, $5,200 per year for amortization of $82,000 capital cost of removal, $32,600 per year for amortization of the $514,200 capital cost of the detention reservoir, representing that portion of the total capital cost of $630,100 of the reservoir that could be fairly allocated to the Village of Elm Grove, and $5,100 annual operation and maintenance expenditures for the detention reservoir which is that portion of the total $6,200 annual operation and maintenance expenditures that would be assumed by the Village of Elm Grove. The average annual flood abatement benefit along Underwood Creek in the Village of Elm Grove is estimated at $362,800, yielding a benefit-cost ratio of 4.86 and an excess of annual costs over benefits of about $288,100. Therefore, the composite detention storage-structure floodproofing and removal measure, as described herein would be both technically and economically feasible within the Village of Elm Grove.

Positive aspects of this combination detention storage-structure floodproofing and removal measure include: 1) consistency with the recommended floodland management subelement for the City of Brookfield in that the Brookfield subelement requires development of the upstream detention storage, 2) immediate partial flood relief at the discretion of property owners through structure floodproofing and removal, and 3) elimination of the need for channel modifications, thus satisfying the objections of Village officials.

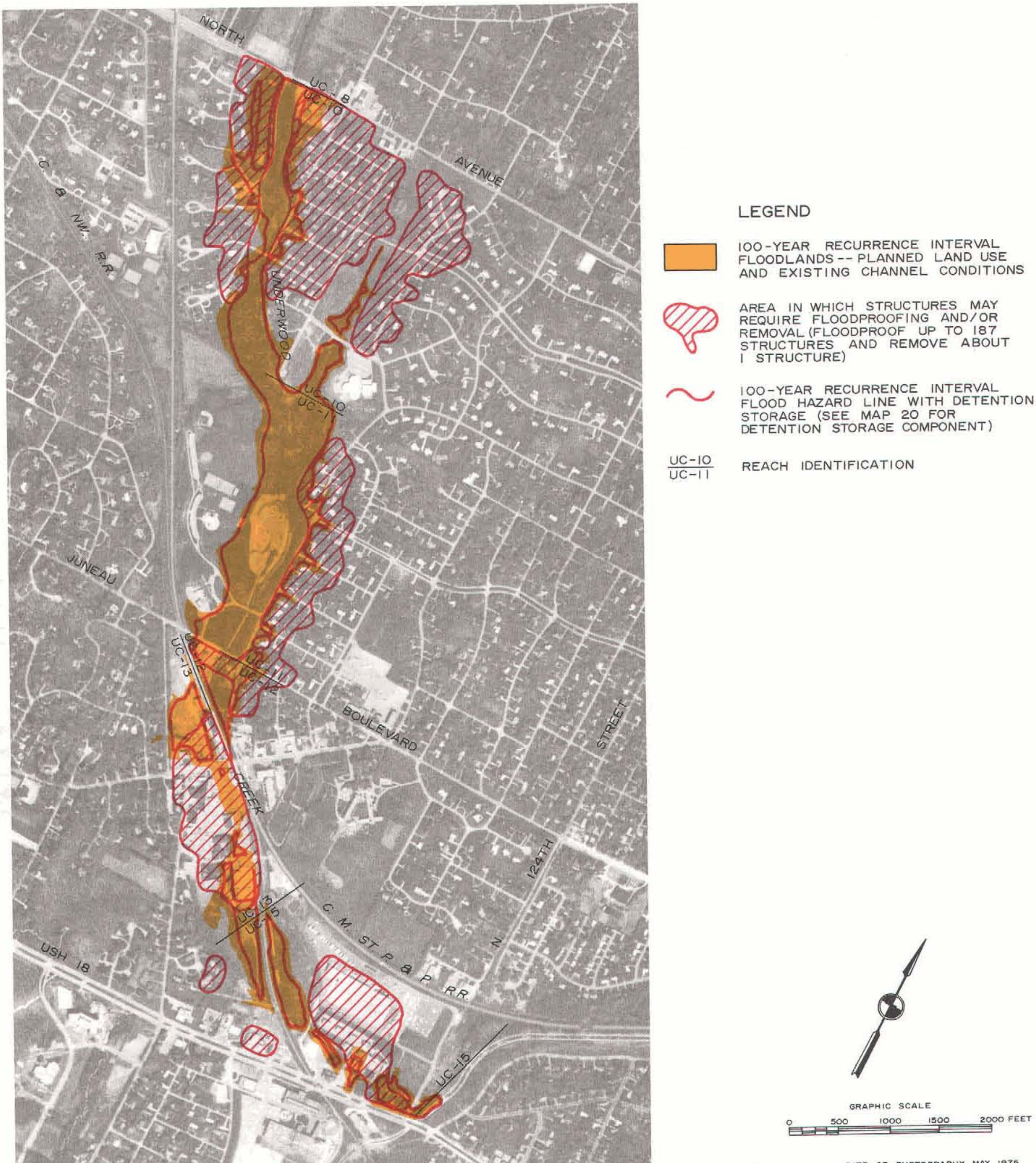
The most serious negative feature of the detention storage-structure floodproofing and removal measure is that complete, voluntary implementation of the structure floodproofing and removal components is unlikely and, with partial implementation, the Village of Elm Grove would be left with a significant residual problem whenever a major flood event occurs. In spite of the fact that numerous individual property owners may have implemented floodproofing and incurred the necessary cost, community officials still may be faced with the problem of reducing the flood threat to those structures that have not been voluntarily floodproofed. Furthermore, even if the voluntary structure floodproofing program were completely and successfully carried out, the Village of Elm Grove would still be subjected to extensive overland flooding that would hamper routine access to and from some riverine area structures, would continue periodically to close local streets to automobile traffic, would interfere with the rapid movement of emergency vehicles, and would continue to aggravate sanitary sewer clear water inflow and infiltration conditions and some attendant sewer surcharge and basement flooding. Furthermore, yard and street damage and cleanup costs would remain. Finally, some floodproofing is very likely to be applied without adequate professional advice. As a result, structure damage is likely to occur and once again Village officials are likely to be asked to assist in the resolution of the problem.

Action of the Menomonee River Watershed Committee: After due reconsideration of the various technical and economic features and other aspects of the nine alternative floodland management measures originally analyzed for the Village of Elm Grove and after consideration of the additional detention storage-structure floodproofing and removal alternative examined subsequent to the informational meetings and the public hearing, the Menomonee River Watershed Committee recommended that the detention storage-structure floodproofing and removal alternative be used to resolve existing and forecast flood problems along Underwood Creek in the Village of Elm Grove.

This decision was heavily influenced by the formal objection to channel modifications by Village officials. In making this recommendation, which is fundamentally different than the original storage-major channelization-

Map 55

DETENTION STORAGE AND STRUCTURE FLOODPROOFING AND REMOVAL ALONG UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE



In order to abate flood problems along Underwood Creek within the Village of Elm Grove, the preliminary watershed plan recommended a combination of an upstream detention reservoir, major and intermediate channelization along Underwood Creek through the Village, and supplemental structure floodproofing. After the informational meetings and public hearing on the preliminary watershed plan, the Village of Elm Grove, based on aesthetic and financial considerations, indicated its opposition to any form of channelization along Underwood Creek within the Village. Accordingly, the Menomonee River Watershed Committee considered, and recommended for implementation, an additional alternative under which the upstream detention storage would be retained, the channel modifications eliminated, and the extent of structure floodproofing and removal increased. More specifically, protection for a flood as severe as the 100-year recurrence interval event under year 2000 planned land use conditions would be achieved through development of the upstream detention reservoir in combination with—as shown above—the floodproofing of up to 187 structures—164 residential and 23 commercial and other structures—and the possible removal of one structure.

Source: SEWRPC.

intermediate channelization-floodproofing recommendation, the Menomonee River Watershed Committee noted that implementation of the detention storage-structure floodproofing and removal measure in lieu of the original recommendation has no significant watershedwide implications. That is, inasmuch as both measures contain the detention reservoir on Dousman Ditch, supplemental flood control measures implemented by the Village of Elm Grove will have no significant upstream or downstream effect on flood flows, stages, or damages in other watershed communities.

It is imperative that all floodproofing measures, irrespective of the structure types involved, be applied under the guidance of a qualified registered engineer. Failure to utilize adequate professional supervision is likely to resolve in damage to the structure and perhaps endanger structure occupants during a major flood event.

Chapter IV of this volume includes a simulation analysis of the impact of the recommended structural flood control works on 100-year recurrence interval flood flows under year 2000 land use plan conditions. The analysis indicated up to a 10 percent increase in 100-year flood flows along the lower Menomonee River. Elimination of the recommendations to carry out intermediate and major channelization along Underwood Creek within the Village of Elm Grove may be expected to yield flood flows along the lower Menomonee River that are less than the up to 10 percent increase expected with the Underwood Creek channel modifications. It would be prudent, however, to design the recommended flood control works along the lower Menomonee River in the Cities of Wauwatosa and Milwaukee to pass flood flows commensurate with the channelization recommended along Lilly Creek and the Menomonee River in the Village of Menomonee Falls, the detention storage recommended along Dousman Ditch in the City of Brookfield, and the channelization originally recommended along Underwood Creek in the Village of Elm Grove. Such design at very little cost would provide greater flexibility in considering future flood control actions within the watershed.

Reconsideration of Flood Control Recommendations Along the Menomonee River and Lilly Creek in the Village of Menomonee Falls

The above sections discuss the Menomonee River Watershed Committee's reconsideration of channelization recommendations for the City of Wauwatosa and the Village of Elm Grove. The published record of the informational meetings and the public hearing indicates some opposition to major channelization anywhere in the watershed. In addition to Wauwatosa and Elm Grove, the only other civil division in the watershed in which major channelization was proposed in the preliminary comprehensive plan for the Menomonee River Watershed was the Village of Menomonee Falls. Accordingly, the Menomonee River Watershed Committee reconsidered its earlier channel recommendations for Menomonee Falls.

More specifically, the preliminary recommendations call for a total of 7.57 miles of major channel improvements, consisting of channelization of the 1.35-mile-long reach of the Menomonee River bounded by the Washington-Waukesha County line at the upstream end and Menomonee Falls Dam at the downstream end; channelization of the 3.25-mile-long reach of the Menomonee River bounded at the upstream end by Arthur Avenue and at the downstream end by the Waukesha-Milwaukee County line; and channelization of the 2.97-mile-long reach of Lilly Creek bounded at the upstream end by W. Silver Spring Drive and at the downstream end by the Menomonee River.

As described in detail in Chapter IV of this volume, an assessment of the above major channelization found it to be technically feasible but uneconomic from a flood control perspective. That detailed assessment also identified important nontechnical and noneconomic factors to be considered such as the aesthetic impact of the channel works. An overriding consideration, however, in the Watershed Committee's original recommendations to implement channel modifications within the Village of Menomonee Falls was the opinion of the Village Engineer that such channel improvements represent an already committed decision in the sense that significant local construction funds have been expended for urban storm sewers and considerable effort has gone into local storm drainage system plans, all of which are based on the grade of the locally proposed channel modifications along portions of the Menomonee River and Lilly Creek.

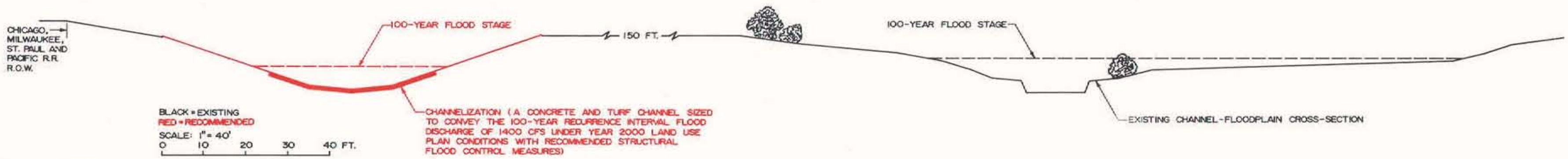
Therefore, in light of the Village commitment to channelization as reflected by the location, size, and grades of existing and proposed storm sewers and storm water outfalls, the Menomonee River Watershed Committee reconfirmed the original recommendation that the channelization alternative be used to resolve existing and probable future flood problems along the Menomonee River and Lilly Creek within the Village of Menomonee Falls.

Representative Cross Sections for River Reaches in Which Channelization is Recommended

Consideration of the record of the informational meetings and the public hearing indicated that some public officials and interested citizens had difficulty visualizing the vertical and horizontal extent and overall size of recommended channel modifications, particularly with reference to existing channel-floodplain topographic conditions. The representative channel-floodplain cross sections shown in Figures 50 to 52 were prepared to better illustrate the size of the originally recommended major channel modifications in the Village of Elm Grove along Underwood Creek downstream of Juneau Boulevard and the recommended major channel modifications along the main stem of the Menomonee River and along Lilly Creek in the Village of Menomonee Falls. These representative cross sections are intended to supplement Figure 15 in Chapter IV of this volume which illustrates the existing channel-floodplain cross section and the originally recommended intermediate channelization in the Village of Elm Grove along Underwood Creek upstream of Juneau Boulevard; and the channel-floodplain cross section shown in Figure 48 of this chapter which illustrates the existing and originally recommended

Figure 50

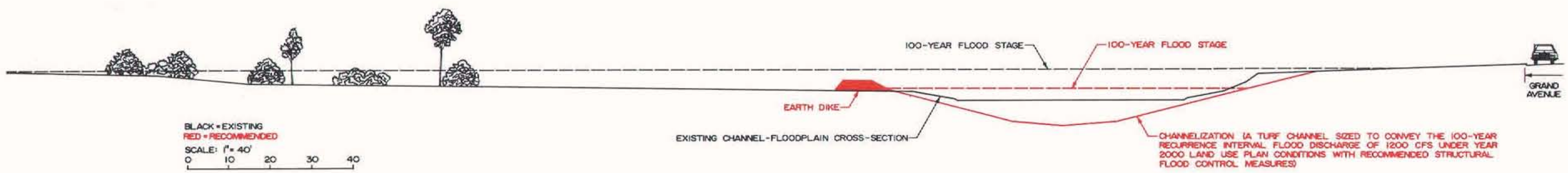
CROSS SECTIONS CORRESPONDING TO EXISTING TOPOGRAPHIC CONDITIONS AND MAJOR CHANNELIZATION-STORAGE COMBINATION AT RIVER MILE 3.08 ON UNDERWOOD CREEK IN THE VILLAGE OF ELM GROVE



Source: SEWRPC.

Figure 51

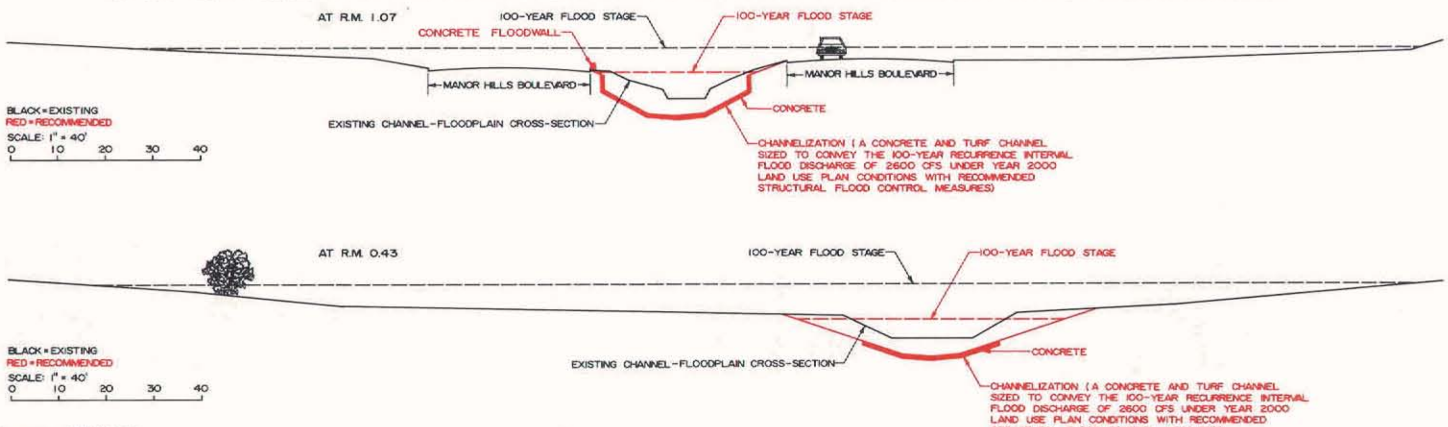
CROSS SECTIONS CORRESPONDING TO EXISTING TOPOGRAPHIC CONDITIONS AND MAJOR CHANNELIZATION AT RIVER MILE 22.54 ON THE MENOMONEE RIVER IN THE VILLAGE OF MENOMONEE FALLS



Source: SEWRPC.

Figure 52

CROSS SECTIONS CORRESPONDING TO EXISTING TOPOGRAPHIC CONDITIONS AND MAJOR CHANNELIZATION AT RIVER MILES 1.07 AND 0.43 ON LILLY CREEK IN THE VILLAGE OF MENOMONEE FALLS



Source: SEWRPC.

channel-floodplain cross section along the Menomonee River in the City of Wauwatosa as well as the channel-floodplain cross section corresponding to the subalternative examined in response to suggestions made at the informational meetings and public hearing.

These representative cross sections of actual channel modifications clearly illustrate the marked change that would be made in riverine area topography as a result of implementation of the originally recommended channel modifications in the Village of Elm Grove, the Village of Menomonee Falls, and the City of Wauwatosa. In order to safely convey the 100-year recurrence interval flood flows under year 2000 planned land use conditions within channel limits, it is necessary to construct an artificial channel that is very large relative to the natural channel section. A major enlargement in channel depth, width, and cross-sectional area is necessitated by the need to convey within the channel that portion of the flood flow that, under natural conditions, occupies the wide, adjacent floodplain which is now occupied by various forms of urban development requiring flood relief.

Photographs of major channel modifications that have already been carried out for flood control purposes within the Menomonee River watershed along Honey Creek, Underwood Creek, and the Menomonee River are shown in Figures 53, 54, and 55, respectively. These examples of major channel modifications indicate that not only do such works effect a marked change in the riverine area topography but they have a range of aesthetic effects depending on such factors as the availability of open "green" space adjacent to the channelized section; the density and variety of trees, shrubs, and other vegetation adjacent to the channelized section; the extent to which architectural treatments have been applied to stream crossings; and the degree to which it was possible to use a curvilinear alignment. Of the three examples of channelization, Honey Creek, as shown in Figure 53, is probably aesthetically most pleasing because of the existence of ample "green" space along both sides of the channel; the presence of a dense and diverse growth of trees, shrubs, and other vegetation along the channel; the application of attractive architectural treatments to stream crossings; and the use of a curvilinear alignment. The Underwood Creek channelization, as shown in Figure 54, has less aesthetic appeal than the Honey Creek channel modifications because of the absence of adequate adjacent "green" space and dense and diverse vegetation in some areas and because of the use of a linear alignment over long reaches of the stream. The Menomonee River channelization, as shown in Figure 55, is probably the least attractive of the three examples because, even though a curvilinear alignment has been used, there is a notable absence of adequate "green" space immediately adjacent to much of the channel; the stream crossings are not pleasing; and unattractive commercial land uses are located in close proximity to much of the channelized reach.

Therefore, while channelization results in a marked change in riverine area topography and certainly detracts from the aesthetic appeal of the riverine area, the degree of the aesthetic impact can be minimized, as illustrated by channelization that has been carried out along Honey Creek within the Menomonee River watershed. Minimization of the aesthetic impact depends on a variety of factors including maintenance of adequate "green" space

Figure 53

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)

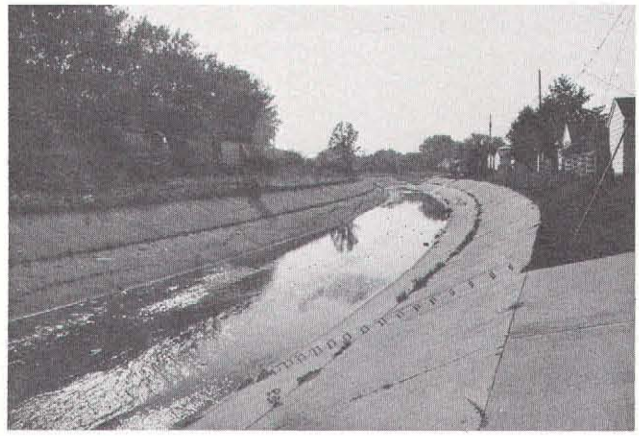
Source: SEWRPC.

Figure 54

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)



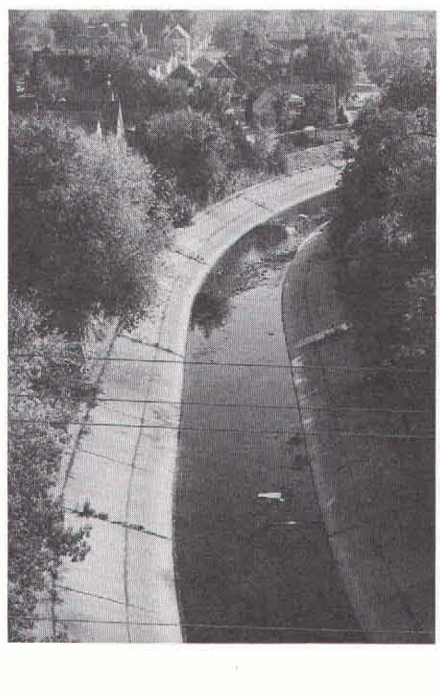
Source: SEWRPC.

Figure 55

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)



Source: SEWRPC.

adjacent to both sides of the channelized reach, retention or provision of a dense and varied vegetation along the channel, incorporation of attractive architectural treatment into the design of stream crossings, and use of curvilinear channel alignments.

Major channel modifications carried out in conformance with the recommendations contained in the comprehensive plan for the Menomonee River watershed should be designed to minimize the aesthetic impact of the channel works while at the same time providing for the safe conveyance of flood flows.

Importance of Maintaining the Conveyance Capacity of Stream Channels

The published record of the informational meetings and public hearing contains repeated comments by concerned private citizens on the need for periodic cleaning and maintenance of the channel portion of the watershed stream system. In response to that expressed concern, it was considered appropriate to reemphasize the need for and discuss the likely positive effects of regular channel maintenance.

As noted in Chapter VIII, Volume 1 of this report, hydraulic, hydrologic, and flood economic analyses completed under the watershed planning program assume that the stream channels and the hydraulic structure waterway openings will be periodically cleaned of debris, heavy vegetation, silt, and other deposits and properly maintained so as to provide at least the amount of conveyance capacity that existed at the time the hydraulic system inventory was conducted for the watershed planning program. Therefore, periodic stream system cleaning and maintenance are important to maintain the integrity of the flood stage profiles developed under the watershed planning program. The second reason for periodic cleaning and maintenance of the stream channels is the need to maintain the channel bottom profile at an elevation below the invert of existing or planned storm sewer outfalls in urban areas and drainage tile and drainage ditch outfalls in rural areas. Failure to provide such cleaning and maintenance may result in partial or full blockage of the outfalls by debris, vegetation, silt, and other deposits in turn causing nuisance or serious flooding of urban areas and of cropland. Finally, cleaning and maintenance of the watershed channel system are important to reduce the probability that buoyant objects and debris such as tree limbs, fence posts, scrap lumber, and brush will be carried downstream with the rising floodwaters and accumulate on the upstream side of bridge and culvert waterway openings, thereby partially blocking them and further increasing flood stages and areas of inundation.

For the above three reasons, the Watershed Committee recommends that civil divisions and governmental agencies within the watershed affected by or having jurisdiction over the watershed stream system carry out periodic cleaning and maintenance of both the stream channels and the bridge and culvert waterway openings. It is important to recognize, however, that the above recommended cleaning and maintenance activities will have no significant effect on the peak stage of major flood events except to reduce the probability of debris accumulating on the upstream side of bridge waterway openings. The insensitivity of peak flood stages to minor channel cleaning and alteration is discussed for major flood events and demonstrated in detail in Chapter IV of this volume in conjunction with the design and analysis of structural flood control measures for the Village of Elm Grove.

A potential conflict exists between the above recommended cleaning and maintenance activities in the channel system and the suggestion, set forth in Chapter V of this volume, to carry out modest localized land and water management measures intended to enhance fish and wildlife habitat along the streams. More specifically, and as described in Chapter V, such management measures might consist of the construction of very low head dams or sills on the stream system to compensate in part for low flow conditions and to lead to the growth of emergent vegetation necessary for good fish and wildlife habitat, to encourage stream aeration, and to provide for entrapment of sediment. While it may not be feasible in a given stream reach both to carry out channel cleaning and maintenance activities on a regular basis and to apply management measures including construction of lowhead dams and sills, it is also unlikely that both of these measures would be required in a given reach. Measures intended to enhance fish and wildlife habitat are most likely to apply to those portions of the stream system—as described in Chapter VI of this volume—that are in a natural or near natural state and do not, therefore, have serious flood problems. The channel cleaning and maintenance activities are more likely to be required and carried out in those river reaches along which urban development has encroached and along which flood problems have developed.

Reconsideration of Land Use Plan Element Recommendation for the City of Mequon

The land use element of the comprehensive plan for the Menomonee River watershed, as originally recommended by the Menomonee River Watershed Committee, recommends, as shown on Map 50, that future land use changes within the Menomonee River watershed portion of the City of Mequon be positively guided so as to retain the existing rural character of the area through continuation of agricultural uses and through development for "country estate" type residential uses with a minimum net lot area of five acres per dwelling unit. While the land use plan element places emphasis upon the land market as the primary determinant of the location, intensity, and character of future development within the basin, it does propose to regulate in the public interest the effect of this market on development in order to provide for a more orderly and economical land use pattern and in order to avoid intensification of already serious development and environmental problems existing within the watershed.

The published record of the informational meeting held in the City of Mequon indicates that, while some farmers in the area opposed the recommended land use plan as it concerns the rural character of the Mequon portion of the watershed, most of the farmers supported retention of the rural, primarily agricultural character of this portion of the watershed provided that tax relief was provided so that continued agricultural use of the land would be more economically feasible. The residents of the existing, scattered residential areas in the Mequon portion of the watershed also supported continuation of the existing rural nature of this area subject to one condition: residents of the Huntington Park subdivision located immediately east of the Little Menomonee River and immediately north of the southern limits of the City of Mequon requested that the land use plan for the watershed reflect the committed decision to expand Huntington Park from its present development of about 30 residential units to its ultimate development of about 200 units. Residents of the scattered subdivisions within the Mequon portion of the watershed as well as some farmers expressed support for the land use plan element partly because this would permit continued enjoyment of the amenities associated with being surrounded by rural land uses and partly because it would avoid increases in flood flows. In summary, the published record of the special informational meeting indicates that both the owners of farmland and developed residential land in the Mequon portion of the watershed support the land use plan element recommendation that the existing rural character of the area be maintained provided that farmers receive tax relief and that the committed decision to expand Huntington Park be recognized.

In spite of the support by landowners for the land use plan element as it affects that portion of the City of Mequon lying within the Menomonee River watershed, City officials expressed concern over restrictions to additional residential development in that area partly because of water supply problems—inadequate well yields due to falling groundwater levels—currently being experienced in the developing southeastern part of the City. These officials believe that additional urban development in those developing areas will aggravate existing groundwater supply problems whereas shifting some new incremental development to the western area of the City of Mequon in the Menomonee River watershed would provide at least temporary relief from aggravation of the water supply problem until a permanent or long-term solution could be obtained. Accordingly, the City officials suggested that the land use plan be amended to permit low-density urban development in the Menomonee River portion of the City of Mequon.

In order to accommodate the concern of the City of Mequon residents and officials, the Menomonee River Watershed Committee recommended that the land use element of the recommended watershed plan be amended to recognize the ultimate development of the Huntington Park subdivision and to permit low-density urban development in the City of Mequon portion of the watershed provided that such development incorporates onsite retention or detention storage of storm water runoff so as to limit peak rates of flow in the Little Menomonee River to levels at or below those that would exist if the existing essentially rural character of the Mequon portion of the watershed were retained. The compensating storm water storage stipulation is critical and was specified by the Watershed Committee because of its concern—based on hydrologic-hydraulic analyses conducted under the watershed planning program—over the certain, adverse effect of urban sprawl in the City of Mequon on flood discharges and stages downstream along the Little Menomonee River in both the City of Mequon and the City of Milwaukee. Through the use of compensating detention or retention storage, the adverse watershedwide impacts of urbanization in the city of Mequon portion of the basin can be minimized.

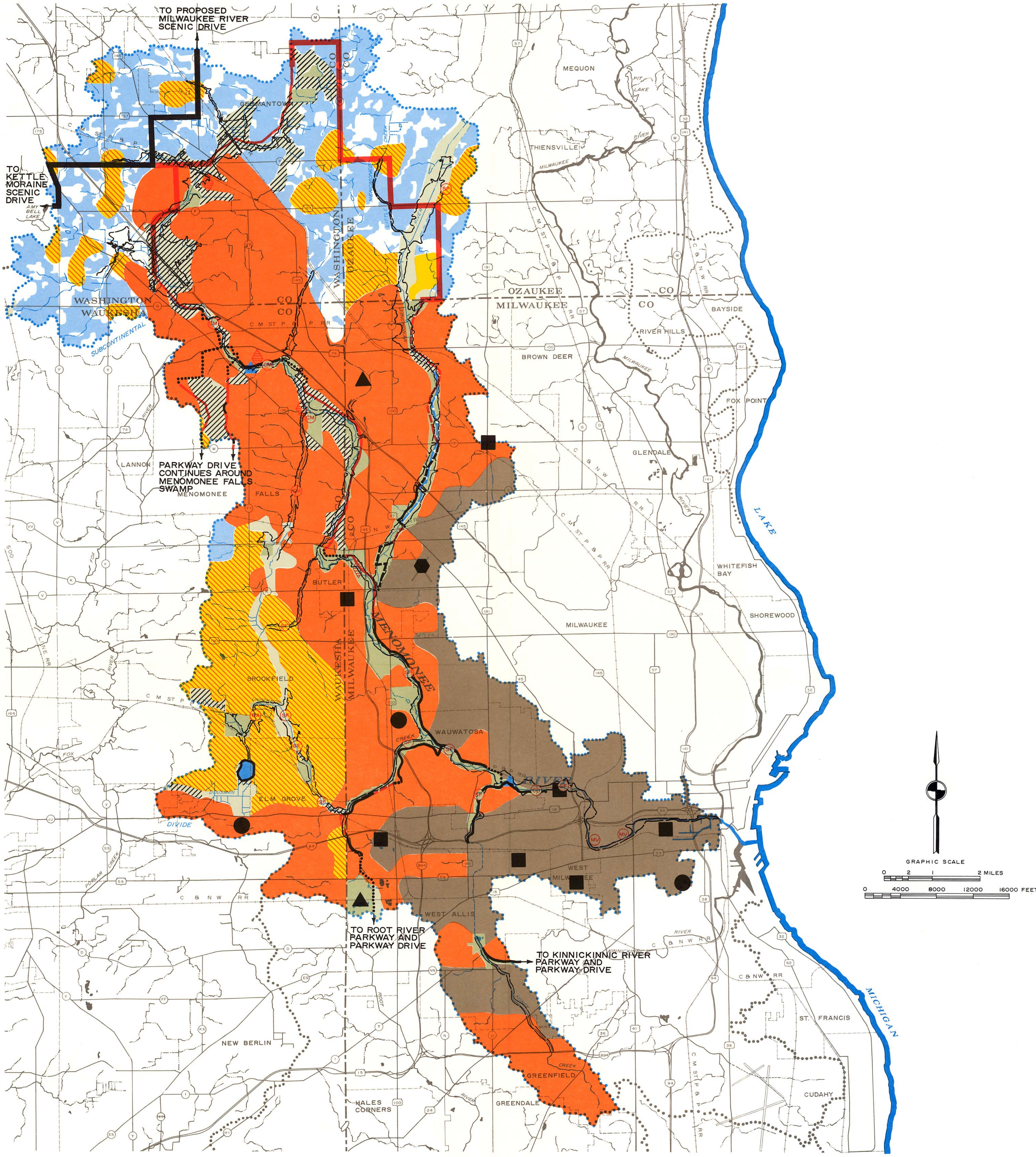
City of Mequon officials also expressed concern over proposed restrictions in the land use plan element on industrial development in the extreme southeastern corner of the City. The recommended land use plan element calls for retaining the existing rural character of the area, whereas the City of Mequon has zoned all of Section 31 and approximately the western one-fifth of Section 32, Township 9 North, Range 21 East, for industrial use. In recognition of the City of Mequon's commitment to permit industrial development, or at least some form of urban development, in Section 31 and the western one-fifth of Section 32, the Menomonee River Watershed Committee recommended that the land use element of the recommended watershed plan be changed so as to indicate urban low-density residential development (0.7-2.2 dwelling units per net residential acre) in that area.

Final Action of the Menomonee River Watershed Committee

After careful consideration of the results of the informational meetings and the public hearing, the Menomonee River Watershed Committee, at a meeting held on October 27, 1976, voted unanimously to recommend to the Regional Planning Commission adoption of the final watershed plan, shown in graphic summary form on Map 56. That plan, as adopted, consisted of the preliminary plan presented at the public informational meetings and public hearing, as described above in this chapter, with the following changes and additions each of which was discussed above:

- That the original recommendation of channelization along the Menomonee River downstream of N. 70th Street in the City of Wauwatosa be changed to a recommendation to use a combination of channelization and dikes and floodwalls and, in a directly related matter, that the original recommendation to floodproof up to 77 commercial and residential structures along the Menomonee River between N. 60th Street Extended and N. 45th Street in the City of Milwaukee be revised so as to recommend the floodproofing of up to 69 commercial and residential structures.
- That the original recommendation of detention storage-intermediate channelization-major channelization-structure floodproofing along Underwood Creek in the Village of Elm Grove be changed to a recommendation to use a combination of detention storage and structure floodproofing.

MAP 56
RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED
2000



LEGEND

LAND USES

- SUBURBAN RESIDENTIAL (0.2–0.6 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- LOW DENSITY URBAN (0.7–2.2 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- MEDIUM DENSITY URBAN (2.3–6.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- HIGH DENSITY URBAN (7.0–17.9 DWELLING UNITS PER NET RESIDENTIAL ACRE)
- AGRICULTURE AND RELATED LAND - SHADED INDICATES LAND HAVING A SLOPE EQUAL TO OR GREATER THAN TWO PERCENT AND LIKELY TO REQUIRE LAND MANAGEMENT
- MAJOR RETAIL AND SERVICE CENTER
- MAJOR INDUSTRIAL CENTER
- MAJOR AIRPORT
- MAJOR PUBLIC OUTDOOR RECREATION CENTER

PRIMARY ENVIRONMENTAL CORRIDOR

- EXISTING PUBLIC OR PRIVATE PARK AND RELATED OPEN SPACE LAND
- PROPOSED FOR PUBLIC AQUISITION
- PROPOSED TO BE PROTECTED THROUGH FLOODLAND AND CONSERVANCY ZONING

PARKWAY DRIVES–SCENIC DRIVES–RECREATIONAL TRAILS

- EXISTING PARKWAY DRIVE
- PROPOSED PARKWAY DRIVE
- EXISTING CONNECTING URBAN STREET
- EXISTING SCENIC DRIVE
- EXISTING CONNECTING RURAL ROADWAY TO BE DESIGNATED SCENIC DRIVE
- EXISTING RECREATIONAL TRAIL
- PROPOSED RECREATIONAL TRAIL

WATER QUALITY MANAGEMENT

- PUBLIC SEWAGE TREATMENT PLANT TO BE ABANDONED
- NEW CHANNEL TO SOLVE CREOSOTE PROBLEM

FLOOD MANAGEMENT

- SF STRUCTURE FLOODPROOFING AND/OR REMOVAL
- CM MAJOR CHANNEL MODIFICATION
- CD CHANNEL MODIFICATION AND DIKE-FLOODWALL CONSTRUCTION
- BA BRIDGE ALTERATION FOR FLOOD DAMAGE MITIGATION
- MV MENOMONEE INDUSTRIAL VALLEY - INCREASED FLOOD PROTECTION ELEVATIONS AND INCREASED HEIGHT OF EXISTING DIKES AND FLOODWALLS
- 100-YEAR RECURRENCE INTERVAL FLOODLANDS
- DETENTION RESERVOIR
- CONTINUOUS RECORDER STREAM GAGE

NOTE: THE FOLLOWING WATER QUALITY MANAGEMENT RECOMMENDATIONS ARE NOT SHOWN ON THIS MAP:

1. FACILITIES NEEDED TO ABATE COMBINED SEWER OVERFLOW POLLUTION FROM THE 10.7 SQUARE MILE COMBINED SEWER SERVICE AREA IN THE LOWER PORTION OF THE WATERSHED
2. ELIMINATION OF SEWAGE FLOW RELIEF DEVICES-CROSSOVERS, BYPASSES, AND RELIEF PUMPING STATIONS-AND INDUSTRIAL DISCHARGES
3. PROVISION OF SANITARY SEWER SERVICE TO APPROXIMATELY 12 SQUARE MILES OF PRESENTLY UNSEWERED URBAN LANDS AND TO ALL-ABOUT 15 SQUARE MILES-PLANNED URBAN DEVELOPMENT
4. INSTALLATIONS OF SYSTEMS FOR THE CONTROL OF POLLUTED RUNOFF FROM 40 BARNYARDS AND FEEDLOTS
5. MEASURES TO REDUCE POLLUTED RUNOFF IN URBAN AREAS
6. PROPOSED MAJOR TRUNK SEWERS AND FORCE MAINS

- That civil divisions and governmental agencies within the watershed affected by, or having jurisdiction over, the watershed stream system carry out periodic cleaning and maintenance of the stream channels and bridge waterway openings.

- That the original recommendation to retain the rural character of that portion of the City of Mequon lying within the watershed be modified to permit low-density urban development on condition that provision is made for compensating detention or retention storage of storm water and that the land use plan incorporate the committed decision to expand the Huntington Park subdivision and to permit industrial development in the extreme southwestern corner of Mequon.

The recommended plan, subject to the above changes and additions, is fully documented in Chapters III, IV, and V of this volume; measures and actions needed to implement the plan are described in Chapter VII; and the recommended plan is summarized in Chapter VIII.

Revisions to the Cost Analysis

As a result of changes made by the Menomonee River Watershed Committee to the floodland management plan element of the preliminary comprehensive plan for the Menomonee River watershed and in order to assist public officials in evaluating the recommended comprehensive Menomonee River watershed plan, a revised capital improvement program with attendant operation and maintenance costs was prepared. If followed, this capital improvement and operation and maintenance program would result in total watershed plan implementation by the year 2000.

Plan Element Costs: The preliminary capital improvement program, revised so as to incorporate post-hearing changes made by the Menomonee River Watershed Committee in the floodland management plan element, includes the staging of necessary land acquisition and facility construction and the distribution of the attendant costs, including operation and maintenance expenditures, over a 24-year period. This expenditure program is presented in summary form for the watershed as a whole in Table 47 and is presented in more detailed form by county and selected civil divisions in a series of tables in Chapter VII of this volume. Table 47 sets forth the land acquisition and construction costs and estimated operation and maintenance expenditures associated with implementation of each of the three recommended plan elements—land use, floodland management, and water quality—and associated subelements by year. As noted above, the schedule of capital and operation and maintenance costs set forth in the tables is based on present (1975) costs for land acquisition, facility construction, and operation and maintenance. Also as noted above, it is estimated that full utilization of financial assistance from the state and federal levels of government could serve to reduce the local plan implementation cost by approximately 50 percent.

The revised full capital investment and operation and maintenance cost of implementing the recommended comprehensive plan for the Menomonee River watershed is estimated at $36.0 million over the 24-year plan implementation period, a $2.8 million, or 7 percent, decrease relative to the total cost of the preliminary plan as presented for public review and comment. Of this total cost, about $10.6 million, or about 29 percent, is required for implementation of the recommended land use plan element which includes the overall land use plan subelement, the primary environmental corridor protection subelement, and the parkway drive-scenic drive-recreational trail subelement. About $14.3 million, or about 40 percent of the full costs associated with the watershed plan, is required for implementation of the recommended floodland management element including recommended channel modifications, detention storage, structure floodproofing and removal, bridge modification, continued operation of the stream gaging network, and miscellaneous flood damage control measures in the industrial valley. About $11.1 million, or about 31 percent of the full cost of implementing the recommended comprehensive watershed plan, is required for implementation of those subelements of the recommended water quality management element not included in other adopted regional plan elements. These subelements consist of the measures proposed to abate the residual creosote pollution problem in the Little Menomonee River, installation of feedlot runoff control systems, and application of land management measures to both rural and urban portions of the watershed for control of diffuse source pollution.

The average annual cost of the total capital investment and operation and maintenance costs required for plan implementation would be approximately $1.50 million, or about $4.08 per capita per year over the 24-year plan implementation period. The per capita cost is based on a resident watershed population of 368,000 persons, equal to the anticipated average resident population of the watershed between the 1970 population level of 348,000 persons and the anticipated year 2000 population level of 388,000 persons. The average annual cost of implementing the land use plan element, the floodland management plan element, and the water quality management plan element is, respectively, about $440,300, or $1.20 per capita; $596,400, or $1.62 per capita; and $463,700, or $1.26 per capita.

The capital and operation and maintenance costs assignable to the land use plan element and the water quality management plan element of the recommended watershed plan are identical to those contained in the preliminary watershed plan as presented for public review at the informational meetings and the public hearing. Costs associated with the floodland management plan element were changed as a result of changes and additions made to the floodland management plan element by the Menomonee River Watershed Committee subsequent to the informational meetings and the public hearing. The revised total capital construction and operation and maintenance cost for the recommended floodland management plan element in the watershed is $14.3 million, a $2.8 million, or a 16 percent, decrease from the total cost of the floodland management plan element in the preliminary comprehensive plan for the watershed. The average annual capital and operation and maintenance cost of implementing the recommended floodland management plan element for the watershed is $596,400, or about $1.62 per capita. This amount would largely be expended for construction of flood control facilities. Of the total estimated cost of $14.3 million for implementation of the floodland management plan element, about $8.6 million, or about 60 percent, would be expended for structural flood control measures—channelization, dikes and floodwalls, detention storage, and bridge modification—with the remaining $5.7 million, or 40 percent, being expended for structure floodproofing and removal, stream gaging, and miscellaneous measures in the industrial valley.

Concluding Statement: As a result of post-hearing changes to the preliminary Menomonee River watershed plan, a slight decrease occurred in the anticipated cost of implementing the floodland management plan element, whereas no changes were made in the costs attendant to the recommended land use and water quality management plan elements. Because of the small change in costs, the conclusion drawn earlier from a comparison of plan costs to selected recent public expenditures remains valid. That analysis concluded that sufficient monies should become available to implement substantially the recommended land use plan element, the floodland management plan element, and the water quality management plan element of the comprehensive Menomonee River watershed plan. However, significant shifts may be required as to where within the watershed such expenditures have been made in the past and where they must be made in the future.

SUMMARY

The various plan subelements recommended as integral parts of the comprehensive plan for the Menomonee River watershed have all been described separately and in considerable detail in the preceding chapters of this volume. This chapter presents a concise description of the overall recommended comprehensive plan of the

Table 47

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED BY PLAN ELEMENT AND BY YEAR: 1977-2000

		Land Use Plan Element							
		Primary Environmental Corridor Subelement		Parkway Drive-Scenic Drive-Recreational Trail Subelement					
				Parkway Drive		Recreational Trail			
Calendar Year	Project Year	Land Acquisition[a]	Operation and Maintenance[b]	Construction[c]	Operation and Maintenance[d]	Construction[e]	Operation and Maintenance[f]	Scenic Drive and Interconnecting Urban Street[g]—Signing and Marking	Subtotal
1977	1	$ 397,860	$ 20,020	$ 212,000	$ 1,580	$ 19,200	$ 310	$ 330	$ 651,300
1978	2	397,860	40,040	212,000	3,160	19,200	630	270	673,160
1979	3	397,860	60,050	212,000	4,760	19,200	930	240	695,040
1980	4	397,860	80,080	212,000	6,340	19,200	1,250	210	716,940
1981	5	397,860	100,100	212,000	7,920	19,200	1,560	180	738,820
1982	6	397,860	120,120	212,000	9,500	19,200	1,870	120	760,670
1983	7	397,860	140,130	212,000	11,080	19,200	2,190	90	782,550
1984	8	397,860	160,160	212,000	12,680	19,200	2,490	90	804,480
1985	9	397,860	180,180	212,000	14,260	19,200	2,810	120	826,440
1986	10	397,860	200,200	212,000	15,840	19,200	3,120	90	848,310
1987	11	--	200,200	--	15,840	--	3,120	90	219,250
1988	12	--	200,200	--	15,840	--	3,120	120	219,280
1989	13	--	200,200	--	15,840	--	3,120	90	219,250
1990	14	--	200,200	--	15,840	--	3,120	90	219,250
1991	15	--	200,200	--	15,840	--	3,120	120	219,280
1992	16	--	200,200	--	15,840	--	3,120	90	219,250
1993	17	--	200,200	--	15,840	--	3,120	90	219,250
1994	18	--	200,200	--	15,840	--	3,120	120	219,280
1995	19	--	200,200	--	15,840	--	3,120	90	219,250
1996	20	--	200,200	--	15,840	--	3,120	90	219,250
1997	21	--	200,200	--	15,840	--	3,120	120	219,280
1998	22	--	200,200	--	15,840	--	3,120	90	219,250
1999	23	--	200,200	--	15,840	--	3,120	90	219,250
2000	24	--	200,200	--	15,840	--	3,120	120	219,280
Total		$3,978,600	$3,903,880	$2,120,000	$308,880	$192,000	$60,840	$3,210	$10,567,410
24-Year Average		$ 165,770	$ 162,660	$ 88,330	$ 12,870	$ 8,000	$ 2,540	$ 134	$ 440,300

Table 47 (continued)

Calendar Year	Project Year	Floodland Management Element: Channel Modifications[h]: Construction	Channel Modifications[h]: Operation and Maintenance	Detention Storage: Construction	Detention Storage: Operation and Maintenance	Structure Floodproofing and Removal	Bridge Modification for Flood Control Purposes	Stream Gaging Network: Operation and Maintenance of Continuous Recorder Gages[i]	Stream Gaging Network: Installation of Staff or Crest Stage Gages[j]	Industrial Valley Measures[k]	Subtotal
1977	1	$1,472,500	$ 2,300	$126,000	$ 1,200	$ 951,500	$ 42,000	$ --	$450	$162,600	$ 2,758,550
1978	2	1,472,500	4,700	126,000	2,500	951,500	42,000	6,400	--	162,600	2,768,200
1979	3	1,472,500	7,000	126,000	3,700	951,500	42,000	6,400	--	162,600	2,771,700
1980	4	1,472,500	9,400	126,000	5,000	951,500	42,000	6,400	--	162,600	2,775,400
1981	5	1,472,500	11,700	126,000	6,200	951,500	42,000	6,400	--	162,600	2,778,900
1982	6	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1983	7	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1984	8	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1985	9	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1986	10	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1987	11	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1988	12	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1989	13	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1990	14	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1991	15	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1992	16	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1993	17	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1994	18	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1995	19	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1996	20	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1997	21	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1998	22	--	11,700	--	6,200	--	--	6,400	--	--	24,300
1999	23	--	11,700	--	6,200	--	--	6,400	--	--	24,300
2000	24	--	11,700	--	6,200	--	--	6,400	--	--	24,300
Total		$7,362,400	$257,400	$630,100	$136,400	$4,757,600	$210,000	$147,200	$450	$813,000	$14,314,550
24-Year Average		$ 306,800	$ 10,700	$ 26,300	$ 5,700	$ 198,200	$ 8,800	$ 6,100	$ 18	$ 33,900	$ 596,400

Calendar Years	Project Years	Water Quality Management Element: Abate Creosote Pollution With Excavation of New Channel and Filling of Existing Channel (Construction)	Control Runoff from Animal Feedlots (Construction)	Reduce Diffuse Source Pollution from Agricultural Lands	Reduce Diffuse Source Pollution from Urban Lands (Operation and Maintenance)	Subtotal	Total
1977	1	$ 40,200	$ 80,000	$ 46,080	$ 429,000	$ 595,280	$ 4,005,130
1978	2	40,200	80,000	46,080	429,000	595,280	4,036,640
1979	3	40,200	80,000	46,080	429,000	595,280	4,062,020
1980	4	40,200	80,000	46,080	429,000	595,280	4,087,620
1981	5	40,200	80,000	46,080	429,000	595,280	4,113,000
1982	6	--	--	--	429,000	429,000	1,213,970
1983	7	--	--	--	429,000	429,000	1,235,850
1984	8	--	--	--	429,000	429,000	1,257,780
1985	9	--	--	--	429,000	429,000	1,279,740
1986	10	--	--	--	429,000	429,000	1,301,610
1987	11	--	--	--	429,000	429,000	672,550
1988	12	--	--	--	429,000	429,000	672,580
1989	13	--	--	--	429,000	429,000	672,550
1990	14	--	--	--	429,000	429,000	672,550
1991	15	--	--	--	429,000	429,000	672,580
1992	16	--	--	--	429,000	429,000	672,550
1993	17	--	--	--	429,000	429,000	672,550
1994	18	--	--	--	429,000	429,000	672,580
1995	19	--	--	--	429,000	429,000	672,550
1996	20	--	--	--	429,000	429,000	672,550
1997	21	--	--	--	429,000	429,000	672,580
1998	22	--	--	--	429,000	429,000	672,550
1999	23	--	--	--	429,000	429,000	672,550
2000	24	--	--	--	429,000	429,000	672,580
Total		$201,000	$400,000	$230,400	$10,296,000	$11,127,400	$36,009,360
24-Year Annual Average		$ 8,400	$ 16,700	$ 9,600	$ 429,000	$ 463,700	$ 1,500,400

[a] Assumes that 10 percent of the recommended 6.3 square miles of primary environmental corridor land would be acquired in each of the first 10 years of plan implementation.

[b] Based on annual operation and maintenance cost of $50 per acre for corridor land.

[c] Assumes that 10 percent of the recommended 13.2 miles of new parkway drive would be constructed in each of the first 10 years of plan implementation.

[d] Based on annual operation and maintenance costs of $1,200 per mile for parkway drives. (Includes snow removal, grass cutting, and sealing of surface.)

[e] Assumes that 10 percent of the recommended 5.2 miles of new recreational trails would be constructed in each of the first 10 years of plan implementation.

[f] Based on annual operation and maintenance costs of $600 per mile for recreational trails.

[g] Assumes that a total of the signs per mile at a cost of $30 per sign would be installed over a five year period on 20.1 miles of scenic drive and interconnecting urban street and that 10 percent of the signs would be replaced each year.

[h] Includes low dikes and floodwalls in the City of Wauwatosa.

[i] Two continuous stage recorder installations each having a total operation and maintenance cost of $3,200 per year.

[j] Nine staff or crest stage gages—one in the City of Mequon in Ozaukee County, two in the Village of Germantown in Washington County, and three in the City of Brookfield and one in the Village of Elm Grove and two in the Village of Menomonee Falls in Waukesha County—at $50 per installation.

[k] Assumes a two foot increase in the height of 0.70 mile of earthen dike along the Menomonee River in the vicinity of the Chicago, Milwaukee, St. Paul, and Pacific Railroad property at $70 per lineal foot; a four foot increase in the height of 0.24 mile of floodwall along the east bank of the Menomonee River between the East-West Freeway and the W. Wisconsin Avenue viaduct at $140 per lineal foot; a four foot increase in the height of 0.16 mile of floodwall along the east bank of the Menomonee River between the W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 4.24 at $140 per lineal foot; and a four foot increase in the height of 0.35 mile of floodwall along parts of both banks of the Menomonee River between the railroad bridge and N. 45th Street at $140 per lineal foot. The estimated capital cost of the total 1.45 miles of dike-floodwall extension is $813,000.

Source: SEWRPC.

Menomonee River watershed intended, in part, to show how each of the three elements—land use, floodland management, and water quality management—complement and strengthen each other.

Under the comprehensive watershed plan recommended herein, future urban development within the watershed would be guided through locally exercised land use controls into a more efficient and attractive pattern. Urban sprawl and continued encroachment of urban development into the natural floodplains would be arrested and future intensification of flood problems would thus be avoided. Residential development would be concentrated within sanitary sewer and public water service areas tributary to existing and proposed systems and would be located on soils suited for such use, thus avoiding future public health, safety, and aesthetic problems. Most of the remaining prime agricultural areas of the watershed would be protected from destruction through urban encroachment. The primary environmental corridors of the watershed, encompassing the best remaining woodland, wetland, and wildlife habitat areas together with the associated undeveloped shorelands and floodlands, would be protected thereby assuring continued enjoyment of the recreational, aesthetic, ecologic, and cultural values associated with the riverine areas. Primary environmental corridor preservation would be accomplished through continued maintenance of existing riverine area of lands used for recreation and other open space uses, by public acquisition of the remaining highest value corridor lands, and by judicious use of floodland and conservancy zoning. Eventually the Menomonee River stream valley would be transformed into an attractive greenbelt composed of parkway, recreation, and other open land areas which would serve to maintain a good environment for life in this urbanizing basin.

The overall land use plan element for the Menomonee River watershed is intended in part to minimize aggravation of existing flood problems. Flood control measures are recommended to abate serious existing and forecast flood problems in the Villages of Elm Grove and Menomonee Falls and in the Cities of Wauwatosa, Brookfield, Mequon, and Milwaukee. Bridge replacement recommendations are included in the plan to assure that major streets, highways, and railroads remain operable during major flood events. Various supplementary measures intended to minimize the monetary losses associated with flooding are recommended including: participation in the federal flood insurance program, continuation of desirable lending institution and realtor policies concerning the sale of riverine areas properties, supportive community utility policies, and the establishment of emergency flood warning programs. Maintenance of a basic stream gaging network is recommended and miscellaneous measures are recommended for mitigation of the residual flood problem in the industrial valley.

The recommended Menomonee River watershed plan incorporates those water quality management measures recommended in other adopted SEWRPC plans which are directly applicable to the Menomonee River watershed including: abandonment of the four remaining municipal sewage treatment plants, abatement of the combined sewer overflow pollution, elimination of flow relief devices, and provision of sanitary sewer service to existing and planned urban development. In addition, industrial discharges to the stream system would be controlled and the residual creosote pollution problem in the Little Menomonee River would be abated under the watershed plan. Land management measures would be invoked to reduce the surface water pollution associated with washoff from rural and urban land surfaces and barnyard runoff pollution control system would be developed.

A preliminary schedule of capital costs and operation and maintenance expenditures was prepared which, if followed, would result in total watershed plan implementation by the year 2000. An analysis of recent actual public expenditures for public works and facilities indicated that the cost of implementing the watershed plan is such as to be reasonably obtainable through continuing the current public expenditure patterns in the basin although some shifts will be necessary within the watershed with respect to where such funds are expended in the future.

An evaluation was made of the comprehensive plan relative to its ability to meet the adopted watershed development objectives and standards. In spite of the highly urbanized nature of this watershed and the associated serious deterioration in the underlying natural resource base, the analysis indicates that vigorous and early implementation of the watershed plan could result in achievement of most of the standards established in support of the adopted watershed development objectives. Implementation of the plan may be expected to provide a safer, healthful, more pleasant, as well as a more orderly and efficient, environment within the watershed.

An evaluation was conducted of the consequences of not implementing the recommended comprehensive plan of the Menomonee River watershed based on analyses carried out under the watershed planning program and on empirical evidence gathered from other portions of the planning region. This evaluation indicates that, in the absence of a vigorous and prompt watershed plan implementation program, the Menomonee River watershed will, because of its urban and urbanizing nature, be particularly susceptible to aggravation of existing water resource and water resource-related problems and to the development of new problems.

Three public informational meetings and a formal public hearing were held subsequent to completion of the preliminary comprehensive watershed plan for the purpose of more fully informing public officials and interested citizens about the plan and obtaining the reactions of those public officials and interested citizens. Public reaction generally was quite favorable to the water pollution abatement and land use recommendations contained in the preliminary plan. Some reservations were expressed about that aspect of the land use plan recommending retention in essentially rural use of that portion of the City of Mequon lying within the watershed. A sharp division of public opinion existed over the best course of action on some of the floodland management recommendations.

After careful consideration of the results of the informational meetings and the public hearing, the Menomonee River Watershed Committee voted to recommend to the Regional Planning Commission adoption of the plan as originally presented at the public informational meetings and public hearing with the following changes and additions: 1) the original recommendation of channelization along the Menomonee River downstream of N. 70th Street in the City of Milwaukee; 2) replacement of the mendation to use a combination of channelization and dikes and floodwalls and, in a directly related manner, a reduction in the extent of structure floodproofing along the Menomonee River between Hawley Road and N. 45th Street in the City of Milwaukee; 2) substitution of the original recommendation to apply major and intermediate channelization along Underwood Creek in the Village of Elm Grove with a recommendation to use structure floodproofing; 3) the addition of a recommendation that civil divisions and governmental agencies within the watershed carry out periodic cleaning and maintenance of the stream channels and bridge waterway openings; 4) retain the original recommendation to keep the rural character of the City of Mequon portion of the watershed but allow for low density urban development on condition that provision is made for compensating detention or retention storage storm water; and 5) revise the land use plan so as to incorporate committed decisions to develop small portions of the City for residential and industrial development.

The full capital investment and operation and maintenance costs of implementing the comprehensive plan for the Menomonee River watershed, based on 1975 costs, are estimated at $36.0 million over the 24-year plan implementation. This total of $36.0 million is a $2.8 million, or 7 percent, decrease relative to the total cost of the preliminary plan as originally presented for public review and comment, with the total cost reduction occurring as a result of post-hearing revisions to the floodland management element of the plan. Of the total $36.0 million cost of the plan, about $10.6 million, or about 29 percent, is required for implementation of the recommended land use plan element; about $14.3 million, or about 40 percent of the full cost, is required for implementation of the floodland management element; and about $11.1 million, or about 31 percent of the full cost of implementing the recommended comprehensive watershed plan, is required for implementation of those subelements of the recommended water quality management element not included in other adopted regional plan elements.

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Chapter VII

PLAN IMPLEMENTATION

INTRODUCTION

The recommended comprehensive plan for the Menomonee River watershed, as described in Chapter VI of this report, provides a design for the attainment of the specific watershed development objectives formulated under the Menomonee River watershed study through the cooperative actions of the local, state, and federal units and agencies of government concerned. The final watershed plan contains three major elements: 1) a land use element, including natural resource base protection, outdoor recreation and related open space, and parkway drive-scenic drive-recreational trail subelements; 2) a supporting floodland management element composed of various structural and nonstructural subelements; and 3) a supporting water quality management element composed of various point and diffuse source pollution abatement subelements.[1]

While the recommended comprehensive plan for the Menomonee River watershed is designed to attain the specified, agreed upon, watershed development objectives, the plan is not complete in a practical sense until the steps required to implement the plan—that is, to convert the plan into action policies and programs—are specified. This chapter, therefore, is presented as a guide for use in the implementation of the Menomonee River watershed plan. Basically, it outlines the actions which must be taken by the various levels and agencies of government concerned if the recommended comprehensive watershed plan is to be fully carried out by the design year 2000. Those units and agencies of government which have plan adoption and plan implementation powers applicable to the Menomonee River watershed plan are identified; necessary or desirable formal plan adoption actions specified; and specific implementation actions are recommended for each of the units and agencies of government with respect to the land use, floodland management, and water quality management plan elements of the comprehensive watershed plan. In addition, financial and technical assistance programs available to such units and agencies of government in the implementation of the watershed plan are discussed.

[1] *The recommended land use plan element as well as the various alternatives that were considered and the process used to arrive at the recommended land use plan element are described in detail in Chapter III of this volume. The recommended floodland management plan element and the water quality management plan element are discussed in a similar fashion in Chapters IV and V, respectively, of this volume. The recommended comprehensive plan for the Menomonee River watershed is described in summary fashion in Chapter VI of this volume.*

PRINCIPLES OF PLAN IMPLEMENTATION

The plan implementation recommendations contained in this chapter are, to the maximum extent possible, based upon, and related to, existing governmental programs and are predicated upon existing enabling legislation. Because of the everpresent possibility of unforeseen changes in economic conditions, state and federal legislation, case law decisions, governmental organization, and tax and fiscal policies, it is not possible to declare once and for all time exactly how a process as complex as watershed plan implementation should be administered and financed. In the continuing regional planning program for southeastern Wisconsin, it will, therefore, be necessary to periodically update not only the watershed plan elements and the data and forecasts on which these plan elements are based, but also the recommendations contained herein for plan implementation.

It is important to recognize that plan implementation measures must not only grow out of formally adopted plans, but must also be based upon a full understanding of the findings and recommendations contained in those plans. Thus, action policies and programs must not only be preceded by formal plan adoption, and, following such adoption, must not only be consistent with the adopted plans, but should also emphasize implementation of the most important and essential elements of the comprehensive watershed plan and those areas of action which will have the greatest impact on guiding and shaping development in accordance with those elements. Of particular importance in this regard are those plan implementation efforts which are most directly related to achieving the basic watershed development objectives, especially those objectives concerned with protection of the underlying and sustaining natural resource base; with flood control and flood damage abatement; and with water quality control and pollution abatement.

Principal Means of Plan Implementation

There are three principal ways in which the necessary watershed plan implementation may be achieved; and these parallel the three functions of the Regional Planning Commission: 1) inventory, or the collection, analysis, and dissemination of basic planning data on a uniform, areawide basis; 2) plan design, or the preparation of a framework of long-range plans for the physical development of the Region; and 3) plan implementation, or the provision of a center for the coordination of planning and plan implementation activities. All require a receptive attitude and active planning and plan implementation programs at the local, county, and state levels of government.

A great deal can be achieved in guiding watershed development into a more desirable pattern through the simple task of collecting, analyzing, and disseminating basic planning and engineering data on a continuing, uniform, areawide basis. Experience within the Southeastern Wisconsin Region to date has shown that, if this important inventory function is properly carried out, the resulting information will be used and acted upon both by local and state agencies of government and by private investors. Since such data were used as a primary input to the preparation of the Menomonee River watershed plan, the use of these data in arriving at development decisions on a day-to-day basis will tend to contribute substantially toward implementation of the recommended watershed plan.

With respect of the function of plan preparation or design, it is essential that some of the watershed plan elements be carried into greater depth and detail for sound implementation. Specifically, the plan recommendations dealing with structural flood control measures and pollution abatement facilities must be carried through preliminary engineering to the final design stages. Further study must be given to the actual geographic limits of the public land acquisitions and land use controls necessary to protect adequately the primary environmental corridors and the high-value wetlands and woodlands. The preparation of such detailed plans will require the continuing development of very close working relationships between the Commission, the county boards concerned, the local units of government concerned, and certain special-purpose units or agencies of government and state agencies and, in particular, the Wisconsin Department of Natural Resources.

To achieve a high degree of watershed plan implementation it will be essential to effectively carry out the Commission's function as a center for the coordination of local, areawide, state, and federal planning and plan implementation activities within the watershed. The community assistance program, through which the Commission upon request actively assists the local municipalities in the preparation of local plans and plan implementation devices, is an important factor in this function and, if properly utilized, will make possible the full integration of watershed and local plans, adjusting the details of the latter to the broader framework of the former.

Distinction Between the Systems Planning, Preliminary Engineering, and Final Design Phases of the Public Works Development Process

The planning process used to prepare the Menomonee River watershed plan constituted the first, or systems planning phase, of what may be regarded as a three-phase public works development process. Preliminary engineering is the second phase in this sequential process with final design being the third and last phase. Inasmuch as effective implementation of the Menomonee River watershed plan requires an understanding of this three-phased process, that process is briefly described below. Although emphasis is placed on use of the process in preparing a comprehensive plan for the Menomonee River watershed and in the subsequent steps needed to advance that plan toward implementation, it is important to note that the three-phased process is applicable to any regional or subregional plan containing recommendations concerning development of public works for flood control, pollution abatement, water supply, sanitary sewerage, transportation, park and open space, and other public facilities and services.

Systems Planning: The systems planning phase concentrates on the precise definition of the problems to be addressed and the development and evaluation of alternative measures for resolution of these problems on a sound areawide basis. Systems planning is intended to permit the selection, from among the alternative measures considered, of the most effective measure that resolves the problem in accordance with agreed upon objectives and supporting standards. In this first or systems planning phase, each alternative measure is developed to sufficient detail to permit a sound, consistent comparison of the technical practicality and economic feasibility of each alternative considered and a proper evaluation of its nontechnical and noneconomic characteristics.

Properly conducted, systems planning is comprehensive in three ways. First, systems planning is comprehensive in the sense that it takes into consideration the entire system and attendant rational planning area most likely to significantly influence the environmental and developmental problems of concern and the sound resolution of those problems. Water and water resource-related problems, for example, should be approached on a watershed basis inasmuch as the watershed system is the most rational planning area for such problems. Man's land use and development activities in one portion of a watershed can markedly influence the severity of environmental problems in other areas of the basin, as illustrated in Chapter IV of this report by the impact of urban development outside of and within the watershed floodland on downstream flood discharges, stages, and expected damages.

Secondly, properly conducted systems planning is comprehensive in the sense that it considers not only the immediate problem but the relationship of the problem to broad land use, socio-economic, and environmental considerations. For example, comprehensive watershed planning recognizes that the quantity and quality of the surface waters in the watershed system are determined in part by existing and planned land use in the watershed system and that land use is, in turn, determined by socio-economic conditions within as well as outside of the watershed. Therefore, the regional land use plan is taken as a "given" in the preparation of the watershed plan so as to reflect regional land use, socio-economic, and environmental conditions likely to influence the cause of and solution to water resource problems within the watershed.

Thirdly, the systems planning phase of the three-phase public works development process is comprehensive in the sense that a full spectrum of potential solutions to the water resource and water resource-related problems are considered during the process. Because of the many measures, variations on measures, and combinations of measures that are available, it is recognized in the systems planning phase that there is an almost unlimited number of solutions to a given problem that, in effect, form a continuum of possible solutions. The key to efficient systems planning is not to examine each of the many possible alternative measures but rather to examine alternatives that define the boundaries of the continuum and also are truly representative of the full range of available measures within the continuum. For example, after defining the flood problems in the Menomonee River watershed in terms of location and severity, the systems planning efforts were directed at an examination of potentially feasible structural and nonstructural means of resolving those flood problems. Various combinations of five structural flood control measures and 10 nonstructural measures were used to synthesize representative alternatives, each of which was then subjected to various degrees of analysis concerning their technical practicality, economic feasibility, environmental impact, and public acceptability. The above process as carried out under the Menomonee River watershed planning program led to the quantification of a serious, historic flood problem in the City of Wauwatosa along the Menomonee River downstream of N. 70th Street. After an evaluation of six alternative measures—floodwater storage, floodwater diversion, structure floodproofing and removal, major channelization, earthen dikes and concrete floodwalls, and a channelization-dike and floodwall combination—it was recommended that channelization in combination with low dikes and floodwalls be used to resolve existing and forecast flood problems in this reach.

Preliminary Engineering

Although systems planning requires considerable effort, systems planning is not normally carried to the level of detail needed to permit immediate implementation of the recommended measures. In general, it is essential that the analysis of the technical, economic, environmental, and other features of the plan elements be carried into greater detail and depth as another step toward implementation. This second phase of the three-phase public works development process is referred to as preliminary engineering and is most properly carried out, subsequent to the adoption of the areawide systems plan by implementing governmental units and agencies, by either the staff of those governmental units and agencies or by engineering and planning consultants retained by one or more of the governmental units and agencies concerned.

The preliminary engineering phase should begin where the systems planning phase ends, and the analysis is no longer comprehensive. Emphasis is now placed on function in that the preliminary engineering phase concentrates on the basic solution to the problem at hand, as that problem and solution have been identified in the systems planning phase. The preliminary engineering phase of the three-phase public works development process presumes that the optimum solution in terms of technical practicality, economic feasibility, and environmental consequences and other considerations has been identified under the previous systems planning phase. Preliminary engineering concentrates on examining variations on the recommended solution and on examining the technical, economic, environmental, and other features of those variations in depth in order to determine the best way to carry out the recommended solution.

As noted above, systems planning carried out under the Menomonee River watershed planning program recommended that major channelization in combination with low dikes and floodwalls be used to resolve the existing and forecast flood problem in the City of Wauwatosa along the Menomonee River downstream of N. 70th Street. Assuming that this recommendation is formally adopted by the City of Wauwatosa, the Milwaukee County Board, the Milwaukee County Park Commission, and the Milwaukee-Metropolitan Sewerage Commissions, a preliminary engineering study would be conducted by the staff of the Milwaukee-Metropolitan Sewerage Commissions or of the City of Wauwatosa or by a consulting firm retained by either of these two governmental units, working with the Milwaukee County Park Commission. The preliminary engineering study would focus on the channelization-dike and floodwall recommendation and proceed on the premise that that solution, as resulting from the systems planning phase, was in fact the most desirable approach.

Starting with the general description of the channelization-dike floodwall alternative as set forth in the Menomonee River watershed planning report, the preliminary engineering investigation would include an onsite investigation of topography, vegetation, soil conditions, and bedrock. Alternative alignments for the channelized section and the earthen dikes and concrete floodwalls would be examined as would alternative channel-floodplain cross-section configurations. The systems planning phase identified the need for storm water pumping stations and backwater gates on four existing storm sewer outfalls and, therefore, the preliminary engineering study would examine various means of providing for pumping of storm water over the dikes into the channelized stream and for preventing the backup of floodwaters from the Menomonee River into low lying areas via the storm sewer system. Potential sources of construction materials would be identified for the selected channelization-dike floodwall system and a preliminary staged construction schedule would be developed taking into account the availability of materials, the nature of the construction activity, and the expected duration of the construction season. Detailed cost estimates would be prepared for the selected channelization-dike and floodwall system, and possible means and sources of financing would be documented. The preliminary engineering investigation would also identify those governmental units and agencies that may have review responsibility in the implementation of the channelization-dike floodwall system and would prepare a preliminary schedule setting forth the responsibilities of the implementing agencies in obtaining the necessary review and approval. The results of the preliminary engineering phase would be set forth in a detailed report submitted for review and approval, after possible revision, by the governmental units and agencies affected.

Final Design: Upon acceptance of the preliminary engineering report by the governmental units and agencies affected, the third or final design phase of the public works development process is initiated. This work would be carried out either by the staff of one or more of the governmental units or agencies involved or by a consulting firm retained by those governmental units or agencies.

Starting with the solution to the problem at hand as set forth in the final, approved version of the preliminary engineering report, the final design phase would move towards the development of detailed construction plans and specifications needed to completely implement the recommended solution. In the case of a public works project involving construction, the plans and specifications would be carried to sufficient detail not only to permit potential contractors to submit bids for the project but also to permit those contractors to actually construct the recommended works. Engineers retained to carry out the final phase may also have responsibility for securing the necessary permits and other approvals from regulatory and review agencies, for providing supervisory and inspection services during the actual construction process, and for certifying to the governmental units and agencies involved that the construction is carried out in accordance with the design provisions and in accordance with the specifications.

In the case of the recommended channelization-dike floodwall measure in the City of Wauwatosa along the Menomonee River downstream of N. 70th Street, the final design phase would result in a set of construction drawings showing the exact channel bottom profile, the shape of the channel and overbank cross-sections, and the location and vertical and horizontal extent of the dikes and floodwalls. These detailed drawings would identify vegetation to be left undisturbed during the construction project and would include detailed plans for additional landscape work. The final design document would include quantification of materials to be excavated and of fill material required as well as a detailed schedule of the type, quantity, and quality of other construction materials such as concrete, reinforcing steel, subbase gravel, and backfill required to carry out the construction project.

Other Considerations: The three-phased public works development process does not always, for a variety of reasons, proceed in the simple three-step fashion as described above. In some situations an iterative process is set in motion requiring a reexamination of an earlier step. For example, during the preliminary engineering phase it is possible that, due to development of additional information, a new alternative is developed that was not considered in the first or systems planning phase and must now be subjected to such an analysis.

Ever-changing federal and state regulations and guidelines can disrupt the three-phased public works development process. This is particularly true if a significant change in those regulations and guidelines occurs subsequent to the systems planning phase and prior to or during the preliminary engineering phase, thus necessitating an iteration back to the systems planning phase to reconsider measures considered during that phase or to analyze additional measures as may be necessitated by the regulation and guideline changes. As a result of the passage of time between the systems planning phase and the preliminary engineering phase, significant changes may occur in the explicitly stated or implicitly expressed values and objectives of elected officials and concerned citizens. In an environment of changing values and objectives, it is possible that a solution to an environmental problem that was originally accepted as optimum—based on systems planning techniques and an agreed-upon set of objectives—could now, because of changing values and objectives, be rejected or encounter considerable opposition necessitating an iteration back to the systems planning phase.

Effective functioning of the three-phase public works development process is highly dependent on close cooperation between governmental units and agencies. For example, the systems level planning conducted by the Southeastern Wisconsin Regional Planning Commission must be acceptable to local governmental units and agencies in order to prompt the latter to undertake the necessary second or preliminary engineering phase and in order that those investigations might make full use of the recommendations resulting from the first or systems planning phase of the public works development process. Systems planning conducted under the Menomonee River watershed planning program resulted in the recommendation that various combinations of channelization, detention storage, dikes and floodwalls, and structure floodproofing and removal be used to resolve existing flood problems in the Menomonee River watershed. The planning process carried out during preparation of the watershed plan will be fruitful only if that systems level planning is accepteble to the county, city, and village governmental units affected to the extent that it prompts them to adopt the plan and to conduct the necessary preliminary engineering studies based on the plan recommendations.

In some special situations the public works development process can be carried out without proceeding through the above three phases. For example, systems planning in the area of floodland management may lead to the recommendation that structure floodproofing and removal be used to resolve flood problems, as is the case in the Menomonee River watershed for the Cities of Brookfield, Wauwatosa, Milwaukee, and Mequon and the Villages of Elm Grove and Butler. In those instances, assuming adoption of the plan recommendations by the governmental units and agencies affected, the preliminary engineering phase can be combined with the final design phase, the goal of which is to provide a precise identification of structures requiring floodproofing and those requiring removal and the manner that floodproofing and removal shall be carried out.

Another complication in the three-phase systems planning-preliminary engineering-final design process described above is the tendency to circumvent a critical step, usually the systems planning phase, in response to intense public concern and controversy over a pressing environmental or developmental problem. This approach sometimes achieves short term gains in that it leads to prompt problem solving activity—for example, minor channel work to "solve" a flood problem—thereby satisfying the immediate public concern. Unfortunately, circumvention of key steps in the public works development process often leads to long term losses as a result of the failure to fully identify and quantify the problem at hand and to determine the most effective solution to that problem in terms of technical practicality, economic feasibility, and environmental impact. Superposition of man's works and activities on the natural resource base produces an urban ecosystem that is complicated in terms of its many and varied components and processes and the interrelationships between those components and processes—an ecosystem that usually defies simple solutions to the environmental and developmental problems that arise.

Review Responsibility of the Regional Planning Commission

Under the provisions of recently enacted federal legislation and subsequent federal administrative determinations,[2] applications by state and local units of government for federal grants in partial support of the planning, acquisition of land for, and the construction of such public works facilitates as sewerage and water supply systems, parks, waste treatment facilities, and soil and water conservation projects must be submitted to an officially designated areawide planning agency for review, comment, and recommendation before consideration by the administering federal agency. The comments and recommendations of the areawide planning agency must include information concerning the extent to which the proposed project is consistent with the comprehensive planning program for the Region, including, in southeastern Wisconsin, the Menomonee River watershed planning program, and the extent to which such a project contributes to the fulfillment of such planning programs. The review comments and recommendations by the areawide planning agency are entirely advisory to the local, state, and federal agencies of government concerned and are intended to provide a basis for achieving the necessary coordination of public development programs in urbanizing regions of the United States on a voluntary, cooperative basis. If used properly, such review can be of material assistance in achieving implementation of the recommended Menomonee River watershed plan.

In this respect, it should be noted that the Regional Planning Commission has formally adopted a policy statement on review of applications for federal grants-in-aid. This policy requires that adopted plan elements, such as a comprehensive watershed plan, form the basis for review and comment by the Commission. All projects that are the subject of applications are certified as being in conformance with and serving to implement, not in conflict with, or in conflict with, adopted regional plan elements.

Finally, it is extremely important that local public officials and concerned citizens recognize that the failure *to implement* any major element of the recommended comprehensive watershed plan will proportionately reduce the capability of the watershed to provide a pleasant, safe, and healthful place in which to live and work. In addition, it is essential that the state and federal implementing agencies recognize that the watersheds of southeastern Wisconsin, and particularly the Menomonee River watershed, are located in that part of the State of Wisconsin wherein reside the largest concentration of its people, where the degree of natural resource base destruction has been greatest, and where existing demands on the resource base are highest.

PLAN IMPLEMENTATION ORGANIZATIONS

Although the Regional Planning Commission can promote and encourage watershed plan implementation in various ways, as discussed above, the completely advisory role of the Commission makes actual implementation of the recommended Menomonee River watershed plan entirely dependent upon action by certain local, areawide, state, and federal agencies of government. Examination of the various agencies that are available under existing enabling legislation to implement the recommended watershed plan reveals an array of departments, commissions, committees, boards, and districts at all levels of government. These agencies range from general-purpose local units of government, such as cities, villages, and towns, to special-purpose districts, such as metropolitan sewerage districts and flood control boards; to state regulatory bodies, such as the Wisconsin Department of Natural Resources; and to federal agencies that provide financial and technical assistance for plan implementation, such as the U. S. Soil Conservation Service.

Because of the many and varied agencies in existence, it becomes exceedingly important to identify those agencies having the legal authority and financial capability to most effectively implement the recommended watershed plan elements. Accordingly, those agencies whose actions will have significant effect either directly or indirectly upon the successful implementation of the recommended comprehensive watershed plan and whose full cooperation in plan implementation will be essential

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[2] *Section 204 of the Demonstration Cities and Development Act of 1966; Title IV of the Intergovernmental Cooperation Act of 1968; and U. S. Office of Management and Budget Circular No. A-94 (Revised), dated January 13, 1976.*

are listed and discussed below.[3] The agencies are, for convenience, discussed by level of government; however, the interdependence between the various levels as well as between agencies of government and the need for close intergovernmental cooperation cannot be overemphasized. Most of the agencies needed for implementation of the recommended watershed plan are already in existence within the watershed. The creation of new agencies for watershed plan implementation should, therefore, be considered only if such agencies are absolutely essential; and, if essential, the creation of the new agencies should be in such form as to complement and supplement most effectively the plan implementation activities of the agencies already in existence.

Watershed Committee

Since planning at its best is a continuing function, a public body should remain on the scene to coordinate and advise on the execution of the watershed plan and to undertake plan updating and renovation as necessitated by changing events. Although the Regional Planning Commission is charged with, and will perform, this continuing areawide planning function, it cannot do so properly without the active participation and support of local governmental officials through an appropriate advisory committee structure. It is, therefore, recommended that the Menomonee River Watershed Committee be reconstituted as a continuing intergovernmental advisory committee to provide a focus for the coordination of all levels of government in the execution of the Menomonee River watershed plan. The Menomonee River Watershed Committee would thus continue to be a creation of the Southeastern Wisconsin Regional Planning Commission, pursuant to Section 66.945 (7) of the Wisconsin Statutes, and would report directly to the Commission. It is recommended that all agency representatives and individuals currently serving on the Menomonee River Watershed Committee remain as members of the continuing committee and that the question of committee membership be left open so that additional members could be added to the Committee as appropriate.

Local Level Agencies

Statutory provisions exist for the creation at the county and municipal level of the following agencies having planning and plan implementation powers important to comprehensive watershed plan implementation, including police powers and acquisition, condemnation (eminent domain), and construction (tax appropriation) powers.

County Park and Planning Agencies: County units of government have a great deal of flexibility available in forming agencies to perform the park and outdoor recreation and zoning and planning functions within the county. Counties may organize park commissions or park and planning commissions pursuant to Section 27.02 of the Wisconsin Statutes. In addition, counties may elect to utilize instead committees of the county board to perform the park and outdoor recreation and zoning and planning functions. The powers are essentially the same no matter how an individual county chooses to organize these functions. If, however, a county elects to establish a county park or county park and planning commission, these commissions have the obligation to prepare a county park system plan and a county street and highway system plan. There is no similar mandate for plan preparation when a county elects to handle these functions with committees of the county board.

The four counties comprising the Menomonee River watershed have chosen to perform the park and outdoor recreation and planning and zoning functions in similar ways. In Milwaukee County there is a County Park Commission with full authority and responsibility for park and parkway acquisition, development, operation, and maintenance. Because Milwaukee County contains no unincorporated area, there is no county zoning authority. The Milwaukee County Park Commission, however, does perform a limited subdivision review function with respect to subdivision plats lying in, or adjacent to, proposed park and parkway developments. Milwaukee County has also created a County Planning Commission to perform, essentially, a capital budgeting and programming function. This planning commission reviews all requests for capital improvements by Milwaukee County agencies. In Ozaukee County responsibility for park and parkway acquisition, development, operation, and maintenance has been assigned to the Ozaukee County Park Commission. Recently, Ozaukee County, which has had up to the present a long history of nonparticipation in land use planning and development, preferring instead to leave that function at the town level of government, enacted a county shoreland and floodland zoning ordinance. This action was required by state legislation enacted in 1965 (Sections 59.971 and 87.30 of the Wisconsin Statutes) and the enactment of the county ordinance may indicate the beginning of a new county attitude toward land use planning. Responsibility for the administration of this ordinance was assigned to a Zoning Committee of the County Board, and administration is carried out by a Zoning Administrator.

Washington County created in 1967 a County Park and Planning Commission with full zoning, subdivision plat review, and park functions. Similarly, in Waukesha County, the County Park and Planning Commission is assigned all county zoning, subdivision plat review, and park functions.

In addition to having the obligation to prepare a county park system plan and a county street and highway system plan, county park and planning commissions

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[3] *A more detailed discussion of the duties and functions of local, areawide, and state agencies as they relate to plan implementation may be found in SEWRPC Technical Report No. 2, Water Law in Southeastern Wisconsin; SEWRPC Technical Report No. 6, Planning Law in Southeastern Wisconsin; and SEWRPC Planning Guide No. 4, Organization of Planning Agencies.*

may be used to prepare and administer county shoreland, floodland, and comprehensive land use zoning ordinances and to administer county subdivision plat review. Such commissions are empowered to acquire, develop, maintain, and operate county parks and other open space land. The existence of a county park and planning commission in each county in the watershed is, therefore, highly desirable for proper implementation of the recommended watershed plan, especially with respect to the natural resource protection, park and outdoor recreation, and general land use recommendations.

It is, therefore, recommended that the Ozaukee County Board of Supervisors consider the recreation and reconstitution of its existing Park Commission, pursuant to Section 27.02 of the Wisconsin Statutes, assigning to it all duties relating to planning, zoning, subdivision plat review, sanitary codes, and modified official mapping, as well as the county park acquisition and development function. Such an Ozaukee County Park and Planning Commission would have, along with the existing Park Commission in Milwaukee County and the existing Park and Planning Commissions in Washington and Waukesha Counties, primary responsibility for implementing the land use and floodland management elements of the Menomonee River watershed plan within the Southeastern Wisconsin Region. A model ordinance creating a county park and planning commission may be found in SEWRPC Planning Guide No. 4, Organization of Local Planning Agencies, Appendix E. Sections 27.03(2), 27.06, and 59.97 of the Wisconsin Statutes provide for the staffing and financing of such commissions.

County Highway Committees: County highway committees of the county board are required in every county of Wisconsin pursuant to Section 83.015 of the Wisconsin Statutes. In Milwaukee County this requirement is met through the Transportation and Public Works Committee, whereas in Ozaukee, Washington, and Waukesha Counties, a County Highway Committee exists. Each county highway committee is given the responsibility of laying out, constructing, and maintaining all county highways as authorized by the county board of supervisors. The county highway committees work in close cooperation with the Wisconsin Department of Transportation, Division of Highways. County highway committees in each of the four counties of the watershed can play an important role in implementation of the Menomonee River watershed plan with respect to the construction and reconstruction of bridges and other highway facilities within the watershed and the designation and marking of a system of parkway and scenic drives throughout the Menomonee River watershed.

Municipal Planning Agencies: Municipal planning agencies include city, village, and town park boards or plan commissions created pursuant to Sections 27.08, 27.13, 62.23(1), 61.35, and 60.18(12) of the Wisconsin Statutes. Such agencies may be used to supplement the actions of the county park and planning commissions or other county park and planning agencies in implementation of the various elements of the proposed Menomonee River watershed plan. An extended discussion of the extent and limitations of the power of these agencies may be found in SEWRPC Planning Guide No. 4, Organization of Planning Agencies. All the local units of government in the Menomonee River watershed have established planning commissions in accordance with Section 62.23 of the Wisconsin Statutes.

Municipal Utility and Sanitary Districts: A municipal utility and sanitary district may be created by cities, villages, and towns pursuant to Sections 66.072, 60.30, 61.36, 62.18, and 198.22 of the Wisconsin Statutes and is authorized to plan, design, construct, operate, and maintain various public sanitary sewer and water supply systems. Such districts have an important plan implementation function to perform with respect to the pollution abatement elements of the Menomonee River watershed plan. As of January 1, 1976, there were established the following two village sanitary districts in the watershed: Village of Elm Grove Sanitary District No. 1 and Village of Elm Grove Sewerage District No. 2.[4]

Soil and Water Conservation Districts: The importance of proper soil and water conservation and management practices to the full implementation of the land use, floodland management and water quality management elements of the Menomonee River watershed plan cannot be overemphasized. Lack of such practices will have a critical adverse effect upon land use, water quality, drainage and flood control, and recreational pursuits within the watershed. Soil and water conservation districts, as authorized under Section 92.05 of the Wisconsin Statutes, have the authority to develop plans for the conservation of soil and water resources, prevention of soil erosion, and prevention of floods and the districts have the authority to request their county board of supervisors to adopt special land use regulations that would implement such plans in unincorporated areas. Such adoption, however, must follow a referendum in which a simple majority of the electors residing in the area to be affected, and who have voted in the referendum, have approved the proposed regulations. Soil and water conservation districts have the authority to acquire through eminent domain any property or rights therein for watershed protection, soil and water conservation, flood prevention works, and fish and wildlife conservation and recreational works, all of which may be construed under federal Public Law 83-566, as amended, as part of the watershed plan implementation program.

Soil and water conservation districts are by law in Wisconsin made geographically coterminous with counties, and all of the four counties in the Menomonee River watershed concerned with implementation of the Menomonee River watershed plan have created such districts. All of these districts have entered into basic and supplemental memoranda of understanding with the U. S.

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[4] *The Village of Elm Grove Sanitary District No. 1 and the Village of Elm Grove Sewerage District No. 2 merged to form the Village of Elm Grove Sewer District on May 1, 1976.*

Department of Agriculture, Soil Conservation Service, for technical assistance. Thus, there exists within the watershed the duly constituted bodies required to represent the counties of the watershed in those agricultural, conservation, and land management programs which are administered by state and federal agencies.

Harbor Commissions: The authority to develop and operate harbors and make harbor improvements is granted to every municipality in Wisconsin having navigable waters within or adjoining its boundaries by Section 30.30 through 30.38 of the Wisconsin Statutes. Such authority may be exercised directly by the governing body of the municipality or by a board of harbor commissioners created for that purpose. Under the authority, the boards of harbor commissioners are authorized to create or improve inner or outer harbor turning basins, slips, canals, and other waterways; to construct, maintain, or repair dock walls and shore protection walls; and to plan, construct, operate, and maintain docks, wharves, warehouses, piers, and related port facilities. Boards of harbor commissioners also may serve as a regulatory enforcement agency for the municipality for dock wall construction and shoreline encroachment. The City of Milwaukee Common Council has created a Board of Harbor Commissioners to exercise such authority. The geographic jurisdiction of the Milwaukee Board of Harbor Commissioners within the Menomonee River watershed implicitly extends along the Menomonee River from its confluence with the Milwaukee River upstream to the fixed railroad bridges at approximately S. 26th and W. Canal Streets and includes the South Menomonee Canal and the Burnham Canal.

Areawide Agencies

Except as noted below, statutory provisions exist for the creation of the following multicounty or other areawide agencies having both general and specific planning and plan implementation powers essential to the implementation of the Menomonee River watershed plan.

Milwaukee Metropolitan Sewerage Commissions: The Metropolitan Sewerage Commission of the County of Milwaukee, which operates and exists pursuant to the provisions of Section 59.96 of the Wisconsin Statutes, has the power to project, plan, and construct main sewers and pumping and temporary disposal works for the collection and transmission of domestic, industrial, and other sanitary sewage to and into the intercepting sewer system of the district. The Metropolitan Sewerage Commission furthermore may improve any watercourse within the district by deepening, widening, or otherwise changing the same where it may be necessary in order to carry off surface waters or drainage waters. The Metropolitan Sewerage Commission, however, may only exercise its powers outside the City of Milwaukee. The Sewerage Commission of the City of Milwaukee, on the other hand, may build treatment plants and build main and intercepting sewers and may improve watercourses in its area of operation, which is within the City of Milwaukee. Only four civil divisions within the Menomonee River watershed do not lie within the Metropolitan Sewerage District of the County of Milwaukee or its existing contract service area. These are: the Towns of Richfield and Germantown in Washington County and the Towns of Brookfield and Lisbon in Waukesha County.

County Drainage Boards and Districts: Chapter 88 of the Wisconsin Statutes authorizes landowners to petition the county court to establish a drainage district under the control of the county drainage board. Such districts are intended to provide for the execution of specific areawide drainage improvements. A drainage district may lie in more than one municipality and in more than one county. The cost of any drainage improvements is assessed against the lands that are specifically benefited. As discussed in Chapter III of Volume 1 of this report, there are five legally established drainage districts lying partially within the Menomonee River watershed. However, only one of these districts—the Jackson-Germantown Drainage District—remains active within the watershed.

Flood Control Boards: Chapter 87 of the Wisconsin Statutes provides for property owners living in a single drainage area to petition for the formation of a flood control board for the sole purpose of effecting flood control measures. Application for the formation of such a board must be made through the Wisconsin Department of Natural Resources. The flood control boards are empowered to straighten, widen, deepen, and otherwise alter watercourses and build flood control works, all activities being subject to review by, and approval of, the Wisconsin Department of Natural Resources.

Comprehensive River Basin District: One possibility for areawide flood control, water quality, and land use plan implementation is the establishment of a special comprehensive river basin district embracing the entire watershed and capable of raising revenues through taxation and bonding; acquiring land; constructing and operating any necessary facilities; and otherwise dealing with the wide range of problems, alternatives, and projects inherent in comprehensive watershed planning. Such a district might be specifically charged in the enabling legislation by which it is created with carrying out the plans formulated under the Menomonee River watershed study. Although enabling legislation to permit the creation of such districts has been proposed to the Wisconsin Legislature in the past, such legislation has not, to date, been adopted, and thus is not presently available as a means of dealing with the watershed plan implementation problem.

Cooperative Contract Commissions: Section 66.30 of the Wisconsin Statutes provides that municipalities[5] may contract with each other to form cooperative service commissions for the joint provision of any services or joint exercise of any powers that such municipality may be authorized to exercise separately; and such com-

[5] *The term municipality under this section of the statutes is defined to include the state, any agency thereof, cities, villages, towns, counties, school districts, and regional planning commissions.*

missions have been given bonding powers for the purposes of acquiring, developing, and equipping land, buildings, and facilities for areawide projects. Significant economies can often be effected through providing governmental services and facilities on a cooperative, areawide basis. Moreover, the nature of certain developmental and environmental problems often requires that solutions be approached on an areawide basis. Such an approach may be efficiently and economically provided through the use of a cooperative contract commission.

Excellent examples of the use of the cooperative contract commission technique within the Menomonee River watershed are the Underwood Sewer Commission, cooperatively established by contract between the City of Brookfield and the Village of Elm Grove for the purpose of providing for the construction, operation, and maintenance of a sanitary interceptor sewer along Underwood Creek, and the Menomonee South Sewerage Commission, established cooperatively between the City of Brookfield and the Village of Menomonee Falls for the purpose of providing for the construction, operation, and maintenance of a sanitary intercepting sewer along Butler Ditch. Intergovernmental cooperation under such cooperative contract commissions may range from the sharing of expensive public works equipment through the construction, operation, and maintenance of major public works facilities on an areawide basis. A cooperative contract commission may be created for the purpose of watershed plan implementation and may be utilized in lieu of any of the aforementioned areawide organizations for such implementation. A model agreement creating a cooperative contract commission is provided in SEWRPC Technical Report No. 6, Planning Law in Southeastern Wisconsin, Appendix A.

Regional Planning Commission: Although not a plan implementation agency itself, one other areawide agency warrants comment, that is, the Regional Planning Commission itself. As already noted, the Commission has no statutory plan implementation powers. In its role, however, as a coordinating agency for planning and development activities within the Southeastern Wisconsin Region, the Commission may play an important role in plan implementation through community planning assistance services and through the review of federal and state grants-in-aid and by using adopted plan elements as a basis for this review. In addition, the Commission provides a basis for the creation and continued functioning of the Menomonee River Watershed Committee, which Committee should remain as an important continuing public planning organization in the watershed.

State Level Agencies

In existence at the state level are the following agencies that either have general or specific planning authority and hold certain plan implementation powers important to the adoption and implementation of the comprehensive Menomonee River watershed plan.

Wisconsin Department of Natural Resources: This Department has broad authority and responsibility in the areas of park development, natural resources protection, water quality control, and water regulation. As such, it combines the park development and land-based natural resource protection functions of the former State Conservation Commission and the water regulatory functions formerly assigned to the State Public Service Commission. The Department has the obligation to prepare a comprehensive statewide plan for outdoor recreation; to develop long-range, statewide conservation and water resource plans; the authority to designate such sites, as necessary, to protect, develop, and regulate the use of state parks, forests, fish, game, lakes, streams, certain plant life, and other outdoor resources; the authority to acquire conservation and scenic easements; and the authority to administer the federal grant program known as the Land and Water Conservation Fund within the State, as well as the park and open-space grant funds available under the State Outdoor Recreation Act Program (ORAP). The Secretary of the Department has, pursuant to federal planning guidelines, the responsibility of certifying to the U.S. Environmental Protection Agency (EPA) river basin, regional, and metropolitan plans for water quality management. Without such certification and subsequent acceptance by the EPA, local units of government within the watershed would lose their eligibility for federal grants-in-aid of the construction of sewage facilities.

As discussed in detail in Chapter X, Volume 1 of this report, the responsibility for water pollution control in Wisconsin is centered in the Wisconsin Department of Natural Resources. The basic authority and accompanying responsibilities relating to the water pollution control function of the Department are set forth in Chapter 144 of the Wisconsin Statutes. Under this chapter the Department is given broad authority to prepare water use objectives and supporting water quality standards; to issue general and specific orders relating to water pollution abatement; to review and approve all plans and specifications for components of sanitary sewerage systems; to conduct research and demonstration projects on sewerage and waste treatment matters; to operate an examining program for the certification of sewage treatment plant operators; to order the installation of centralized sanitary sewerage systems; to review and approve the creation of joint sewerage systems and metropolitan sewerage districts; and to administer a financial assistance program for the construction of pollution prevention and abatement facilities. In addition, under recent legislation[6] the Department is given broad authority to establish and carry out a pollutant discharge elimination program in accordance with the policy guidelines set forth by the U. S. Congress under the Federal Water Pollution Control Act Amendments of 1972. This recent legislation establishes a new waste discharge permit system and provides that no permit may be issued by the Department for any discharge from a point source of pollution which is in conflict with any areawide waste treatment management plan

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[6] *Chapter 74 Wisconsin Laws of 1973. This law created Chapter 147 of the Wisconsin Statutes.*

approved by the Department. Also under this new legislation, the Department is given rule-making authority to establish effluent limitations, water-quality-related limitations, performance standards related to classes or categories of pollution, and toxic and pretreatment effluent standards. All permits issued by the Department must include conditions that waste discharges will meet, as applicable, and include also all effluent limitations, performance standards, effluent prohibitions, pretreatment standards, and any other limitations needed to meet the established water use objectives and supporting water quality standards as developed under areawide waste treatment management planning programs. As appropriate, the permits may require periodic water quality monitoring to determine compliance as well as include a timetable for appropriate action on the part of the owner or operator of any point waste discharge. It is anticipated that this new legislation and accompanying procedures will become the primary enforcement tool of the Wisconsin Department of Natural Resources in achieving the established water use objectives and supporting water quality standards.

Although not feasible under current legislation and state constitutional constraints, it is conceivable that the State itself could assume responsibility for the construction, operation, and maintenance of areawide sewage treatment facilities and major intercommunity trunk sewer systems. Such authority would constitute an important departure from historical practice and tradition in Wisconsin, but would be very similar in concept to the State's role in the transportation field where the Wisconsin Department of Transportation, operating through the State Highway Commission since the early part of this century, has designed, constructed, and maintained those trunk highways essential to provide for intercommunity movement of people and goods.

The Department also has the obligation to establish standards for floodplain and shoreland zoning and the authority to adopt, in the absence of satisfactory local action, shoreland and floodplain zoning ordinances, as well as the authority to prohibit the installation or use of onsite soil absorption sewage disposal systems and to approve the regulation of such systems as promulgated by the Wisconsin Division of Health. In addition, the Department has authority to regulate water diversions, shoreland grading, dredging, encroachments, and deposits in navigable waters; authority to regulate construction of neighboring ponds, lagoons, waterways, stream improvements, and pierhead and bulkhead lines; authority to regulate the construction, maintenance, and abandonment of dams; authority to regulate water levels of navigable lakes and streams and lake and stream improvements, including the removal of certain lake bed materials; and authority to require abatement of water pollution, to administer state financial aid programs for water resource protection, to assign priority for federal aid applications for sewage treatment plants, to review and approve water supply and sewerage systems, and to license well drillers and issue permits for high capacity wells. With such broad authority for the protection of the natural resources of the state and the Region, this Department will be extremely important to implementation of nearly all of the major elements of the comprehensive Menomonee River watershed plan.

Wisconsin Department of Local Affairs and Development: This Department has limited authority to review subdivision plats, proposed municipal incorporations, consolidations, and annexations and to provide technical assistance to local units of government in planning and planning-related matters.

Wisconsin Department of Transportation: This Department is broadly empowered to provide the State with an integrated transportation system. Within the Wisconsin Department of Transportation, the State Highway Commission is charged with the responsibility for administering all state and federal aid for highway improvement; for the planning, design, construction, and maintenance of all state highways; and for planning, laying out, revising, constructing, reconstructing, and maintaining the national interstate and defense highway system, the federal aid primary system, the federal aid secondary system, and the forest highway system, all subject to federal regulation and control. The State Highway Commission is also responsible for reviewing all county trunk highway systems. As such, the State Highway Commission, along with the respective county highway committees of the county boards of supervisors concerned, can play a role in full implementation of the Menomonee River watershed plan with respect to the construction and reconstruction of bridges and other highway facilities within the watershed and the designation and marking of a system of parkway and scenic drives throughout the Menomonee River watershed.

Wisconsin Department of Health and Social Services, Division of Health: This Division has the authority to review subdivision plats not served by public sanitary sewerage systems and to regulate private onsite soil absorption sewage disposal systems.

Wisconsin Board of Soil and Water Conservation Districts: This Board, on behalf of the State, coordinates and assists the programs of the county soil and water conservation districts concerned with the proper development, use, and protection of soil, water, and related natural resources; apportions among the districts any funds allotted from state or federal sources; approves district sponsorship of federally assisted watershed projects authorized under Public Law 566; and approves the participation of drainage boards in federally assisted water management projects.

Federal Level Agencies

There exist at the federal level the following agencies which administer federal aid and assistance programs that can have important effects upon the implementation of the recommended Menomonee River watershed plan because of the potential impact on the financing of both actual land acquisition and construction of specific facilities.

U. S. Department of Housing and Urban Development: This agency administers urban planning grants, flood insurance, and community development block grant programs. The community development block grants are available as entitlement grants to cities of over 50,000 persons and are available as discretionary grants to communities of under 50,000 persons. The community development block grant program and the flood insurance program can be important to implementation of the land use, floodland management, and water quality management elements of the Menomonee River watershed plan.

U. S. Environmental Protection Agency: This agency administers water quality management planning grants and sanitary sewage treatment plant and pollution control facility construction grants. The latter grants can be particularly important to implementation of the water quality management element of the Menomonee River watershed plan. In addition, this agency is responsible for the ultimate enforcement of water quality standards of interstate waters, should the states not adequately enforce such standards. Under guidelines promulgated by this agency, river basin, regional, and metropolitan water quality management plans are required as a condition of the approval and award of federal grants-in-aid of the construction of sewerage facilities.

The U. S. Environmental Protection Agency is also charged with administering Section 208 of the 1972 Federal Water Pollution Control Act. As a designated agency under that program, the Regional Planning Commission is involved in a water quality planning and management program for Southeastern Wisconsin intended to update, extend, and refine the previous studies and plans completed by the Commission and in so doing fully meet the requirements of Section 208 of the Federal Water Pollution Act.

U. S. Department of the Interior, Bureau of Outdoor Recreation: This agency administers park and open space acquisition and development grants through the Federal Land and Water Conservation Fund program. The program is administered in Wisconsin through the Wisconsin Department of Natural Resources. Grants under this program can be particularly important to implementation of the outdoor recreation and open space and natural resource protection subelements of the Menomonee River watershed plan.

U. S. Department of the Interior, Geological Survey: This agency conducts continuing programs on water resource appraisal and monitoring. The programs of the U. S. Geological Survey are particularly important to the implementation of the continuous stream gaging program recommended in the Menomonee River watershed plan.

U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service: This agency administers the Federal Agricultural Conservation Program (ACP), which replaces the Federal Rural Environmental Assistance Program (REAP). This program provides grants to rural landowners in partial support of carrying out approved soil, water, woodland, wildlife, and other conservation practices. These grants are awarded under yearly and long-term assistance programs, providing guaranteed funds for carrying out approved conservation work plans. Grants from the Federal Agricultural Conservation Program can be important to implementation of the water quality management element of the Menomonee River watershed plan.

U. S. Department of Agriculture, Soil Conservation Service: This agency administers resource conservation and development projects and watershed projects under federal Public Law 566 and provides technical and financial assistance through county soil and water conservation districts to landowners in the planning and construction of measures for land treatment, agricultural water management, and flood prevention and for public fish, wildlife, and recreational development. This agency also conducts detailed soil surveys and provides interpretations as a guide to utilizing soil survey data in local planning and development. Certain programs administered by this agency can be of particular importance to implementation of the agricultural land management and treatment measures, as recommended in the Menomonee River watershed plan.

U. S. Department of the Army, Corps of Engineers: This agency can conduct planning studies and construct flood control facilities as authorized by the Congress. In addition, under Section 205 of the Flood Control Act 1948, as amended, the Corps is authorized to contribute to the review, design, and construction phases of selected projects, provided that the maximum Corps of Engineers first cost is one million dollars or less.[7] In the event a project is authorized by the Chief of Engineers within five years of the project area being declared a federal flood disaster area by the President, the Corps of Engineers contribution to the project may be increased to a maximum first cost of two million dollars. While the structural flood control subelements contained in the recommended Menomonee River watershed plan can be implemented largely through existing local agencies and units of government, the potential exists for the Corps of Engineers to play a very important role in the implementation of the floodland management element of the recommended Menomonee River watershed plan, provided that responsible local agencies or units of government request the Corps or Congress to fund a review of the flood control subelements contained in the recommended Menomonee River watershed plan by the Corps of Engineers.[8]

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[7] *The Office of Management and Budget has blocked funding of Section 205, Flood Control Act of 1948, as amended, for F. Y. 1977.*

[8] *The authorization for the Corps of Engineers to conduct such reviews for the Milwaukee River and its tributaries—which includes the Menomonee River watershed—is provided in Section 205, Flood Control Act of 1950, (Title II, P.L. 516—81st Congress), Milwaukee River and Tributaries, Wisconsin.*

PLAN ADOPTION AND INTEGRATION

Upon adoption of the Menomonee River watershed plan by formal resolution of the Southeastern Wisconsin Regional Planning Commission, in accordance with Section 66.945(10) of the Wisconsin Statutes, the Commission will transmit a certified copy of the resolution adopting the watershed plan, together with the plan itself, to all local legislative bodies within the Menomonee River watershed and to all of the aforesaid existing state, local, areawide, and federal agencies that have potential plan implementation functions.

Adoption, endorsement, or formal acknowledgement of the comprehensive watershed plan by the local legislative bodies and the existing local, areawide, state and federal level agencies concerned is highly desirable not only to assure a common understanding among the several governmental levels and to enable their staffs to program the necessary implementation work but because this acceptance or acknowledgement in some cases is required by the Wisconsin Statutes before certain planning actions can proceed, a requirement that holds in the case of city, village, and town plan commissions created pursuant to Section 62.23 of the Wisconsin Statutes. In addition, formal plan adoption may also be required for state and federal financial aid eligibility. A model resolution for adoption of the comprehensive plan for the Menomonee River watershed is included in Appendix G of this volume.

It is extremely important to understand that adoption of the recommended Menomonee River watershed plan by any unit or agency of government pertains only to the statutory duties and functions of the adopting agencies, and such adoption does not and cannot in any way preempt or commit action by another unit or agency of government acting within its own area of functional and geographic jurisdiction. Thus, adoption of the Menomonee River watershed plan by a county would make the plan applicable as a guide, for example, to county park system development but not to any municipal park development within the county. To make the plan applicable as a guide to municipal park development would require its adoption by the municipality concerned.

Upon adoption or endorsement of the Menomonee River watershed plan by a unit or agency of government, it is recommended that the policy-making body of the unit or agency direct its staff to review in detail the plan elements of the comprehensive watershed plan. Once such review is completed, the staff can propose to the policy-making body for its consideration and approval the steps necessary to fully integrate the watershed plan elements into the plans and programs of the unit or agency of government.

Local Level Agencies

1. It is recommended that the Milwaukee County Board formally adopt the comprehensive Menomonee River watershed plan, including the land use elements, the floodland management element, and the water quality management element, by resolution pursuant to Sections 27.04(2) and 66.945(12) of the Wisconsin Statutes after a report and recommendation by the County Park Commission, County Planning Commission, and County Transportation and Public Works Committee.

2. It is recommended that the Ozaukee County Board formally adopt the comprehensive Menomonee River watershed plan, including the land use elements, the floodland management element, and the water quality management element, by resolution pursuant to Sections 27.04(2) and 66.945(12) of the Wisconsin Statutes after a report and recommendation by the County Park Commission, the County Zoning Committee, and the County Highway Committee.

3. It is recommended that the Washington County Board formally adopt the comprehensive Menomonee River watershed plan, including the land use elements, the floodland management element, and the water quality management element, by resolution pursuant to Sections 27.04(2) and 66.945(12) of the Wisconsin Statutes after a report by the County Park and Planning Commission and the County Highway Committee.

4. It is recommended that the Waukesha County Board formally adopt the comprehensive Menomonee River watershed plan, including the land use elements, the floodland management element, and the water quality management element, by resolution pursuant to Sections 27.04(2) and 66.945(12) of the Wisconsin Statutes after a report and recommendation by the County Park and Planning Commission and the County Highway Committee.

5. It is recommended that the plan commissions of all cities, villages, and towns in the watershed adopt the recommended Menomonee River watershed plan as it affects them, by resolution pursuant to Section 62.23(3)(b) of the Wisconsin Statutes and certify such adoption to their respective governing body, and that such governing bodies also adopt the recommended plan.

6. It is recommended that the governing bodies of all municipal water and sanitary districts and utilities formally acknowledge the land use and water quality management elements of the comprehensive Menomonee River watershed plan and determine their utility service areas in accordance with such plan.

7. It is recommended that the County Soil and Water Conservation Districts of Milwaukee, Ozaukee, Washington, and Waukesha Counties adopt those portions of the recommended Menomonee River watershed plan affecting them, so as to establish a broad, well-designed basis for the

development of comprehensive conservation plans under Section 92.08(4) of the Wisconsin Statutes and to assist in establishing eligibility for tax relief and technical and financial assistance.

Areawide Agencies

1. It is recommended that the Metropolitan Sewerage Commission of the County of Milwaukee and the Sewerage Commission of the City of Milwaukee, acting jointly, adopt the recommended Menomonee River watershed plan as such plan affects the work of those bodies.

State Level Agencies

1. It is recommended that the Wisconsin Natural Resources Board endorse the comprehensive Menomonee River watershed plan, certify the plan as an official river basin plan to the U. S. Environmental Protection Agency, and direct its staff in the Wisconsin Department of Natural Resources to integrate the recommended watershed plan elements into its broad range of agency responsibilities, as well as to assist in coordinating plan implementation activities over the next 20 years. In particular, it is recommended that the Natural Resources Board endorse the recommended natural resource protection and outdoor recreation and open space subelements and direct its staff to integrate these plan elements into the long-range conservation and comprehensive outdoor recreation plans authorized by Section 23.09(7) of the Wisconsin Statutes and required by the Federal Land and Water Conservation Act. It is further recommended that the Board, through its staff, coordinate the recommended Menomonee River watershed plan with its activities relating to floodland and shoreland zoning. It is also recommended that the Board and its staff consider and give due weight to the recommended watershed plan in the exercise of their various water regulatory powers. It is further recommended that the Board adopt the detailed soils data and analyses prepared by the U. S. Soil Conservation Service as a guide in regulating soil absorption sewage disposal systems. Finally, it is recommended that the Board endorse the water quality management plan recommendations of the Menomonee River watershed plan and direct its staff to integrate these plan recommendations into its water quality control activities, including the issuance of amended pollution abatement orders to require local units of government to implement the recommendations contained in the Menomonee River watershed plan.

2. It is recommended that the Milwaukee, Ozaukee, Washington, and Waukesha County Drainage Boards, as well as any other drainage board or district created within the watershed subsequent to the publication of this report, formally acknowledge the recommended Menomonee River watershed plan, especially with respect to the land use elements, and the floodland management element.

3. It is recommended that the Wisconsin Department of Local Affairs and Development endorse the recommended Menomonee River watershed plan and integrate the plan into its activities with respect to the provision of technical assistance to local units of government, with respect to reviewing subdivision plats, and with respect to administering federal urban planning grants.

4. It is recommended that the State Highway Commission of the Wisconsin Department of Transportation consider and give due weight to the recommended Menomonee River watershed plan in the exercise of its various responsibilities governing the construction and reconstruction of highway facilities.

5. It is recommended that the Wisconsin Board of Health and Social Services endorse the land use elements and the water quality management elements of the Menomonee River watershed plan and direct its staff to follow the plan recommendations in the exercise of their subdivision plat review and approval powers created by Section 36.13(2)(m) of the Wisconsin Statutes. It is further recommended that the Board direct its staff to utilize the detailed soil survey prepared by the U. S. Department of Agriculture, Soil Conservation Service, as a guide in reviewing and objecting to subdivision plats, in accordance with Section 236.12 of the Wisconsin Statutes. It is further recommended that the Board adopt the detailed soils data and analyses as a guide in regulating soil absorption sewage disposal systems.

6. It is recommended that the Wisconsin Board of Soil and Water Conservation Districts endorse the recommended Menomonee River watershed plan, particularly the agricultural land use, environmental corridor preservation, and other natural resource protection measures, so as to coordinate the County Soil and Water Conservation District program and projects, as required in Section 92.04(4)(c) of the Wisconsin Statutes.

Federal Level Agencies

1. It is recommended that the U. S. Department of Housing and Urban Development endorse the Menomonee River watershed plan and utilize such plan in its administration and granting of federal aids for community development and in the administration of its flood insurance program.

2. It is recommended that the U. S. Environmental Protection Agency formally accept the recommended Menomonee River watershed plan upon State of Wisconsin certification and utilize the

plan recommendations in the administration and granting of federal aids for sewage treatment plants and related facilities.

3. It is recommended that the U. S. Department of the Interior, Bureau of Outdoor Recreation, formally acknowledge the Menomonee River watershed plan and utilize the plan recommendations in its administration and granting of federal aids under the Land and Water Conservation Fund Act.

4. It is recommended that the U. S. Department of the Interior, Geological Survey, endorse the Menomonee River watershed plan and continue, in cooperation with the various counties concerned, its entire water resources investigation program, including the maintenance and upgrading of its stream gaging program within the watershed.

5. It is recommended that the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, formally acknowledge the Menomonee River watershed plan and utilize the plan recommendations in its administration of the Agricultural Conservation program, with particular respect to the various agricultural land management measures and practices.

6. It is recommended that the U. S. Department of Agriculture, Soil Conservation Service, formally acknowledge the Menomonee River watershed plan and utilize the plan recommendations in its administration and granting of federal aids for resource conservation and development and multiple-purpose watershed projects and in its provision of technical assistance to landowners and operators for land and water conservation practices.

7. It is recommended that the U. S. Department of the Army, Corps of Engineers, formally acknowledge the Menomonee River watershed plan. It is further recommended that the Corps of Engineers cooperate with any local or state units and agencies of government in any requests for assistance in the review, design, and construction phases of the floodland management plan elements of the recommended Menomonee River watershed plan.

SUBSEQUENT ADJUSTMENT OF THE PLAN

No plan can be permanent in all of its aspects or precise in all of its elements. The very definition and characteristics of areawide planning suggest that an areawide plan, such as a comprehensive watershed plan, to be viable and of use to local, state, and federal units and agencies of government, be continually adjusted through formal amendments, extensions, additions, and refinements to reflect changing conditions. The Wisconsin Legislature clearly foresaw this when it gave to regional planning commissions the power to "... amend, extend, or add to the master plan or carry any part or subject matter into greater detail..." in Section 66.945(9) of the Wisconsin Statutes.

Amendments, extensions, and additions to the Menomonee River watershed plan will be forthcoming not only from the work of the Commission under various continuing regional planning programs but also from state agencies as they adjust and refine statewide plans and from federal agencies as national policies are established or modified or as new programs are created or as existing programs are expanded or curtailed. Adjustments must also come from local planning programs which, of necessity, must be prepared in greater detail and result in greater refinement of the watershed plan. This is particularly true of the land use element of the watershed plan. Areawide adjustments may come from subsequent regional or state planning programs, which may include additional comprehensive or special-purpose planning efforts, such as the preparation of regional sanitary sewerage service plans, regional water supply plans, and regional or county park and open space plans.

All of these adjustments and refinements will require the utmost cooperation by the local, areawide, state, and federal agencies of government, as well as coordination by the Southeastern Wisconsin Regional Planning Commission, which has been empowered under Section 66.945(8) of the Wisconsin Statutes to act as a coordinating agency for programs and activities of the local units of government. To achieve this coordination between local, state, and federal programs most effectively and efficiently and, therefore, to assure the timely adjustments of the watershed plan, it is recommended that all of the aforesaid state, areawide, and local agencies having various plan and plan implementation powers advise and transmit all subsequent planning studies, plan proposals and amendments, and plan implementation devices to the Southeastern Wisconsin Regional Planning Commission for consideration as to integration into, and adjustment of, the watershed plan. Of particular importance in this respect will be the continuing role of the Menomonee River Watershed Committee in intergovernmental coordination.

LAND USE PLAN ELEMENT IMPLEMENTATION

Introduction

The implementation of the land use plan element—including the overall land use, primary environmental corridor, and parkway drive-scenic drive-recreational trail subelements—of the comprehensive Menomoenee River watershed plan is of central importance to the realization of the overall watershed plan. This element, moreover, requires the most intricate implementation actions and the utmost cooperation between the local units of government and the areawide, state, and federal agencies concerned if the watershed development objectives are to be fully achieved. This is true not only because the land use plan subelements are closely interrelated in nature and support and complement one another, but also because they are closely related to the floodland management and water quality management elements of the plan.

If, for example, urban residential, commercial, and industrial growth is properly located within the watershed and is not allowed to further preempt the natural floodland areas or destroy the remaining wetlands and woodlands, a great deal will be achieved with respect to flood damage-mitigation as well as to natural resource protection. Similarly, if the recommended environmental corridors are protected and acquired for natural resource protection and conservancy purposes, this will, in turn, assure acquisition of many of the best park sites remaining within the watershed. Although all of the plan implementation recommendations are closely interrelated, this section has been divided for convenience, in presentation and use, into the following major subject areas: overall land use plan subelement, primary environmental corridor subelement, and parkway drive-scenic drive-recreational trail subelement. The recommended implementation actions discussed under this plan element are summarized in Table 48, and a schedule of capital and operation and maintenance costs for this plan element is set forth in Table 49.

Overall Land Use Plan Subelement

The overall land use plan subelement of the Menomonee River watershed plan was developed from the land use pattern established in the preparation of the revised and updated regional land use plan for the year 2000.[9] The watershed land use base was further refined through analyses of the findings of the woodland, wetland, and wildlife habitat inventories and the floodland delineations carried out as part of the Menomonee River watershed study. The overall land use plan subelement deals with land use within and outside of the riverine areas of the watershed. The refined land use base in the riverine areas of the watershed is dealt with in additional detail under the primary environmental corridor subelement of the land use plan.

The implementation of the overall land use plan subelement can best be accomplished through the adoption of the recommended regional land use plan and the adoption of the specific recommendations developed following the refinement of the land use base during the Menomonee River Watershed Study. The implementation of the overall land use plan subelement will result in the delineation of zoning districts as a result of the further refinement of the land use base and, as described below, specific recommendations are made to achieve this end.

It is recommended that all cities, villages, towns, and counties within the Menomonee River watershed adopt by resolution the recommended regional land use plan for the year 2000 as refined during the Menomonee River watershed study. It is further recommended that the following methods be used in the implementation of the overall land use plan subelement.

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[9] *SEWRPC Planning Report No. 25, A Regional Land Use Plan and a Regional Transportation Plan for Southeastern Wisconsin—2000, 1976.*

Zoning Ordinances: Of all the land use plan implementation devices, the most readily available, most important, and most versatile is the application of the local police power to the control of land use development through the adoption of appropriate zoning ordinances, including zoning district regulations and zoning district delineations. The following zoning ordinances or amendments to existing zoning ordinances should be adopted by the appropriate county and local units of government within the watershed so as to provide a clear indication of the intent to implement the overall land use plan subelement of the Menomonee River watershed plan and thereby to provide a framework for other planning and plan implementation efforts:

1. It is recommended that the plan commissions of all cities, villages, and towns formulate and recommend to their respective governing bodies new zoning ordinances or amendments to existing zoning ordinances in accordance with Section 60.74 or 62.23(7) of the Wisconsin Statutes so as to provide district regulations, including the exclusive use districts, and floodland and shoreland regulations similar to those provided in the SEWRPC Model Zoning Ordinance, together with appropriate zoning districts map changes, to reflect the recommended watershed land use pattern.

2. It is recommended that the respective municipal governing bodies then adopt such zoning ordinances or amendments thereto, including such zoning district maps or changes thereto, pursuant to Section 60.74 or 62.23(7) of the Wisconsin Statutes.

The task of delineating zoning district boundaries to reflect the land use plan recommendations in the comprehensive Menomonee River watershed plan is as difficult as it is important. Proper delineation of the boundaries of the various zoning districts to achieve the land use pattern recommended in the watershed plan will require careful study and a thorough understanding not only of the local community plan recommendations by the local zoning agencies but also of the watershed plan recommendations and their relationships to the local plans. In this process the primary environmental corridors must be broken down into several zoning districts as necessitated by the various types of natural resources found in such corridors. Moreover, the delineation of zoning districts to reflect immediately the recommended watershed land use plan would result initially in overzoning which may, in turn, result in mixed and uneconomical future land use patterns. Therefore, the use of holding zones, such as exclusive agricultural districts, will be necessary to regulate community growth in both time and space in an orderly and economical manner.

The following recommendations are made to all zoning agencies within the watershed to assist them in the task of zoning ordinance preparation, including zoning district delineation.

Table 48

MATRIX OF MENOMONEE RIVER WATERSHED PLAN ELEMENTS AND IMPLEMENTING GOVERNMENTAL UNITS AND AGENCIES

Plan Elements	Implementing Governmental Units and Agencies																									
		Local Level Agencies and Units of Government																								
	Menomonee River Watershed Committee	City of Brookfield	City of Greenfield	City of Mequon	City of Milwaukee	City of New Berlin	City of Wauwatosa	City of West Allis	Village of Butler	Village of Elm Grove	Village of Germantown	Village of Greendale	Village of Menomonee Falls	Village of West Milwaukee	Town of Brookfield	Town of Germantown	Town of Lisbon	Town of Richfield	Milwaukee County	Ozaukee County	Washington County	Waukesha County	Milwaukee County Soil and Water Conservation District	Ozaukee County Soil and Water Conservation District	Washington County Soil and Water Conservation District	Waukesha County Soil and Water Conservation District
I. Menomonee River Watershed Plan																										
A. Plan Adoption	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
B. Plan Endorsement																										
C. Plan Acknowledgement																										
II. Land Use Plan Element																										
A. Overall Land Use Plan Subelement																										
1. Adopt regional land use plan for the year 2000		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
2. Adopt or amend zoning ordinances to provide special use zoning districts		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X				
B. Primary Environmental Corridor Subelement																										
1. Acquire selected high value primary environmental corridor lands																			X		X	X				
2. Continue or enact protective zoning for selective primary environmental corridor lands		X	X	X	X		X	X	X	X	X		X			X										
3. Continue maintenance of existing public and privately owned open space and recreation lands		X							X	X	X		X						X							
C. Parkway Drive-Scenic Drive-Recreational Trail Subelement																										
1. Maintain existing and construct and maintain new parkway drives																			X		X	X				
2. Mark and sign recommended scenic drives																				X	X					
3. Maintain existing and construct and maintain new recreational trails																			X			X				
4. Mark and sign interconnecting urban streets system																			X			X				
III. Floodland Management Plan Element																										
A. Floodland Regulations Preparation Subelement		X	X	X	X		X	X	X	X	X															
B. Structural Measures for Flood Damage Abatement Subelement													X													
1. Construction and maintenance of a flood detention reservoir		X								X																
2. Stream Channelization[a]							X						X													
3. Adopt floodproofing regulations		X		X	X		X			X																
4. Establish a program for acquisition and removal of structures		X					X			X																
5. Bridge replacement		X																								
C. Bridge Replacement Subelement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
D. Flood Insurance Subelement		X	X	X	X		X	X	X	X	X		X								X	X				
E. Lending Institution and Realtor Policies and Emergency Programs Subelement[b]																										
F. Community Utility Policies and Emergency Programs Subelement		X	X	X	X		X	X	X	X	X		X		X	X		X	X	X	X	X				
G. Streamflow Recordation Subelement		X		X	X					X	X		X									X				
H. Miscellaneous Measures for the Industrial Valley Subelement					X																					
I. Channel Maintenance Subelement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X				
IV. Water Quality Management Plan Element																										
A. Municipal Sewage Treatment Plant Abandonment Subelement									X		X		X													
B. Combined Sewer Overflow Elimination Subelement					X																					
C. Flow Relief Device Elimination Subelement[b]		X			X		X	X					X													
D. Industrial Discharge Elimination Subelement[b]																										
E. Creosote Pollution Abatement Subelement																			X							
F. Onsite Sewage Disposal System Elimination Subelement		X		X	X						X		X		X	X		X								
G. Land Management Subelement		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
H. Continuing Water Monitoring Subelement	X																									

Table 48 (continued)

Plan Elements	Areawide Agencies: Milwaukee-Metropolitan Sewerage Commission	Areawide Agencies: Jackson-Germantown Drainage District	Areawide Agencies: Underwood Sewer Commission	Areawide Agencies: Menomonee South Sewerage Commission	Areawide Agencies: Regional Planning Commission	State Level Agencies: Wisconsin Department of Natural Resources	State Level Agencies: Wisconsin Department of Local Affairs and Development	State Level Agencies: Wisconsin Department of Transportation	State Level Agencies: Wisconsin Department of Health and Social Services	State Level Agencies: Wisconsin Board of Soil and Water Conservation Districts	Federal Level Agencies: U. S. Department of Housing and Urban Development	Federal Level Agencies: U. S. Environmental Protection Agency	Federal Level Agencies: U. S. Department of Interior, Bureau of Outdoor Recreation	Federal Level Agencies: U. S. Department of Interior Geological Survey	Federal Level Agencies: U. S. Department of Agriculture, Agriculture Stabilization and Conservation Service	Federal Level Agencies: U. S. Department of Agriculture Soil Conservation Service	Federal Level Agencies: U. S. Department of the Army, Corps of Engineers
I. Menomonee River Watershed Plan																	
A. Plan Adoption	X		X	X	X												
B. Plan Endorsement						X	X		X	X	X	X		X			
C. Plan Acknowledgement		X						X					X		X	X	X
II. Land Use Plan Element																	
A. Overall Land Use Plan Subelement																	
1. Adopt regional land use plan for the year 2000																	
2. Adopt or amend zoning ordinances to provide special use zoning districts																	
B. Primary Environmental Corridor Subelement																	
1. Acquire selected high value primary environmental corridor lands						X					X		X				
2. Continue or enact protective zoning for selective primary environmental corridor lands																	
3. Continue maintenance of existing public and privately owned open space and recreation lands																	
C. Parkway Drive-Scenic Drive-Recreational Trail Subelement																	
1. Maintain existing and construct and maintain new parkway drives						X		X			X		X				
2. Mark and sign recommended scenic drives								X									
3. Maintain existing and construct and maintain new recreational trails						X					X		X				
4. Mark and sign interconnecting urban streets system								X									
III. Floodland Management Plan Element																	
A. Floodland Regulations Preparation Subelement						X											
B. Structural Measures for Flood Damage Abatement Subelement																	
1. Construction and maintenance of a flood detention reservoir			X			X											
2. Stream Channelization[a]	X		X			X											
3. Adopt floodproofing regulations																	
4. Establish a program for acquisition and removal of structures																	
5. Bridge replacement			X			X											
C. Bridge Replacement Subelement						X		X									
D. Flood Insurance Subelement						X					X						
E. Lending Institution and Realtor Policies and Emergency Programs Subelement[b]																	
F. Community Utility Policies and Emergency Programs Subelement	X		X	X		X		X	X		X	X					
G. Streamflow Recordation Subelement	X					X		X						X			
H. Miscellaneous Measures for the Industrial Valley Subelement	X																
I. Channel Maintenance Subelement	X		X			X		X									
IV. Water Quality Management Plan Element																	
A. Municipal Sewage Treatment Plant Abandonment Subelement	X					X						X					
B. Combined Sewer Overflow Elimination Subelement	X					X						X					
C. Flow Relief Device Elimination Subelement[b]						X						X					
D. Industrial Discharge Elimination Subelement[b]						X						X					
E. Creosote Pollution Abatement Subelement						X											
F. Onsite Sewage Disposal System Elimination Subelement	X					X			X		X	X					
G. Land Management Subelement		X				X						X			X	X	
H. Continuing Water Monitoring Subelement																	

[a] *This section of the structural measures for flood damage abatement subelement includes bridge replacement as necessary.*

[b] *This subelement can be implemented wholly or in part by the private sector.*

Source: SEWRPC.

Residential Areas: Not all of the areas shown as devoted to residential use in the recommended watershed land use plan should be initially placed in residential use districts. Only existing and platted, but not yet fully developed, residential areas and those areas that have immediate development potential and can be economically served by municipal utilities and facilities—such as sanitary sewer, public water supply, and schools—should be placed in exclusive residential districts related to the development densities indicated on the recommended watershed land use plan. The balance of the proposed future residential land use areas should be placed in exclusive agricultural districts so as to act as a holding zone for future development. The use of such holding districts is discussed in SEWRPC Planning Guide No. 3, Zoning Guide. Such holding districts should be rezoned into the appropriate residential zoning district or supporting land use district, such as business, neighborhood, or park districts, only when the community can economically and efficiently accommodate the proposed development. Certain residential areas may be initially zoned, as appropriate, for very low density "country estate" and related outdoor recreational uses. All residential zoning should be properly related to the inherent suitabilities of the underlying soil resource base.

Agricultural Areas: Areas shown as devoted primarily to agricultural use on the recommended watershed land use plan should usually be placed in an exclusive agricultural use district which essentially permits only agricultural uses. In such areas dwellings should be permitted only as accessory to the basic agricultural uses. Significant wetlands, woodlands, floodlands, and wildlife habitat areas that lie outside the delineated primary environmental corridor but within the agricultural use areas on the recommended watershed land use plan should be placed in conservancy districts.

Environmental Corridors: The environmental corridors shown on the recommended watershed land use plan should be placed immediately into one of several zoning districts, as dictated by consideration of existing development; the character of the specific resource values to be protected within the corridor; and the attainment of the outdoor recreation, open space preservation, and resource conservation objectives of the watershed plan. Prime wildlife habitat areas, wetlands, woodlands, and undeveloped floodways and floodplains lying in the corridors should be placed in conservancy districts. Existing and potential park sites lying in the corridors should be placed in park districts which permit the development of appropriate

Table 49

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE LAND USE PLAN ELEMENT OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED BY COUNTY AND YEAR: 1976-2000

					Parkway Drive-Scenic Drive-Recreational Trail Subelement						
			Primary Environmental Corridor Subelement		Parkway Drives		Recreational Trail		Scenic Drive	Interconnecting Urban Street	
County	Calendar Year	Project Year	Land Acquisition[a] (in Dollars)	Operation and Maintenance[b] (in Dollars)	Construction[c] (in Dollars)	Operation and Maintenance[d] (in Dollars)	Construction[e] (in Dollars)	Operation and Maintenance[f] (in Dollars)	Signing and Marking[g] (in Dollars)	Signing and Marking[g] (in Dollars)	Total (in Dollars)
Milwaukee	1977	1	36,460	360	80,750	430	18,300	290	30	30	136,650
	1978	2	36,460	730	80,750	860	18,300	580	--	30	137,710
	1979	3	36,460	1,090	80,750	1,300	18,300	860	--	30	138,790
	1980	4	36,460	1,460	80,750	1,730	18,300	1,150	--	--	139,850
	1981	5	36,460	1,820	80,750	2,160	18,300	1,440	--	--	140,930
	1982	6	36,460	2,190	80,750	2,590	18,300	1,730	--	30	142,050
	1983	7	36,460	2,550	80,750	3,020	18,300	2,020	--	--	143,100
	1984	8	36,460	2,920	80,750	3,460	18,300	2,300	--	--	144,190
	1985	9	36,460	3,290	80,750	3,890	18,300	2,590	--	30	145,310
	1986	10	36,460	3,650	80,750	4,320	18,300	2,880	--	--	146,360
	1987	11	--	3,650	--	4,320	--	2,880	30	--	10,880
	1988	12	--	3,650	--	4,320	--	2,880	--	30	10,880
	1989	13	--	3,650	--	4,320	--	2,880	--	--	10,850
	1990	14	--	3,650	--	4,320	--	2,880	--	--	10,850
	1991	15	--	3,650	--	4,320	--	2,880	--	30	10,880
	1992	16	--	3,650	--	4,320	--	2,880	--	--	10,850
	1993	17	--	3,650	--	4,320	--	2,880	--	--	10,850
	1994	18	--	3,650	--	4,320	--	2,880	--	30	10,880
	1995	19	--	3,650	--	4,320	--	2,880	--	--	10,850
	1996	20	--	3,650	--	4,320	--	2,880	--	--	10,850
	1997	21	--	3,650	--	4,320	--	2,880	30	30	10,910
	1998	22	--	3,650	--	4,320	--	2,880	--	--	10,850
	1999	23	--	3,650	--	4,320	--	2,880	--	--	10,850
	2000	24	--	3,650	--	4,320	--	2,880	--	30	10,880
County Total			364,600	71,160	807,500	84,240	183,000	56,160	90	300	1,567,050
County Annual Average			15,190	2,960	33,650	3,510	7,620	2,340	4	12	65,290

Table 49 (continued)

County	Calendar Year	Project Year	Primary Environmental Corridor Subelement: Land Acquisition[a] (in Dollars)	Primary Environmental Corridor Subelement: Operation and Maintenance[b] (in Dollars)	Parkway Drive-Scenic Drive-Recreational Trail Subelement: Parkway Drives: Construction[c] (in Dollars)	Parkway Drives: Operation and Maintenance[d] (in Dollars)	Recreational Trail: Construction[e] (in Dollars)	Recreational Trail: Operation and Maintenance[f] (in Dollars)	Scenic Drive: Signing and Marking[g] (in Dollars)	Interconnecting Urban Street: Signing and Marking[g] (in Dollars)	Total (in Dollars)
Ozaukee	1977	1	--	--	--	--	--	--	90	--	90
	1978	2	--	--	--	--	--	--	90	--	90
	1979	3	--	--	--	--	--	--	60	--	60
	1980	4	--	--	--	--	--	--	60	--	60
	1981	5	--	--	--	--	--	--	60	--	60
	1982	6	--	--	--	--	--	--	30	--	30
	1983	7	--	--	--	--	--	--	30	--	30
	1984	8	--	--	--	--	--	--	30	--	30
	1985	9	--	--	--	--	--	--	30	--	30
	1986	10	--	--	--	--	--	--	30	--	30
	1987	11	--	--	--	--	--	--	30	--	30
	1988	12	--	--	--	--	--	--	30	--	30
	1989	13	--	--	--	--	--	--	30	--	30
	1990	14	--	--	--	--	--	--	30	--	30
	1991	15	--	--	--	--	--	--	30	--	30
	1992	16	--	--	--	--	--	--	30	--	30
	1993	17	--	--	--	--	--	--	30	--	30
	1994	18	--	--	--	--	--	--	30	--	30
	1995	19	--	--	--	--	--	--	30	--	30
	1996	20	--	--	--	--	--	--	30	--	30
	1997	21	--	--	--	--	--	--	30	--	30
	1998	22	--	--	--	--	--	--	30	--	30
	1999	23	--	--	--	--	--	--	30	--	30
	2000	24	--	--	--	--	--	--	30	--	30
County Total			--	--	--	--	--	--	930	--	930
County Annual Average			--	--	--	--	--	--	40	--	40

County	Calendar Year	Project Year	Primary Environmental Corridor Subelement: Land Acquisition[a] (in Dollars)	Primary Environmental Corridor Subelement: Operation and Maintenance[b] (in Dollars)	Parkway Drive-Scenic Drive-Recreational Trail Subelement: Parkway Drives: Construction[c] (in Dollars)	Parkway Drives: Operation and Maintenance[d] (in Dollars)	Recreational Trail: Construction[e] (in Dollars)	Recreational Trail: Operation and Maintenance[f] (in Dollars)	Scenic Drive: Signing and Marking[g] (in Dollars)	Interconnecting Urban Street: Signing and Marking[g] (in Dollars)	Total (in Dollars)
Washington	1977	1	125,930	12,600	50,000	480	--	--	90	--	189,100
	1978	2	125,930	25,200	50,000	960	--	--	90	--	202,180
	1979	3	125,930	37,800	50,000	1,440	--	--	90	--	215,260
	1980	4	125,930	50,400	50,000	1,920	--	--	90	--	228,340
	1981	5	125,930	63,000	50,000	2,400	--	--	60	--	241,390
	1982	6	125,930	75,600	50,000	2,880	--	--	30	--	254,440
	1983	7	125,930	88,200	50,000	3,360	--	--	30	--	267,520
	1984	8	125,930	100,800	50,000	3,840	--	--	30	--	280,600
	1985	9	125,930	113,400	50,000	4,320	--	--	30	--	293,680
	1986	10	125,930	126,000	50,000	4,800	--	--	30	--	306,760
	1987	11	--	126,000	--	4,800	--	--	30	--	130,830
	1988	12	--	126,000	--	4,800	--	--	30	--	130,830
	1989	13	--	126,000	--	4,800	--	--	30	--	130,830
	1990	14	--	126,000	--	4,800	--	--	30	--	130,830
	1991	15	--	126,000	--	4,800	--	--	30	--	130,830
	1992	16	--	126,000	--	4,800	--	--	30	--	130,830
	1993	17	--	126,000	--	4,800	--	--	30	--	130,830
	1994	18	--	126,000	--	4,800	--	--	30	--	130,830
	1995	19	--	126,000	--	4,800	--	--	30	--	130,830
	1996	20	--	126,000	--	4,800	--	--	30	--	130,830
	1997	21	--	126,000	--	4,800	--	--	30	--	130,830
	1998	22	--	126,000	--	4,800	--	--	30	--	130,830
	1999	23	--	126,000	--	4,800	--	--	30	--	130,830
	2000	24	--	126,000	--	4,800	--	--	30	--	130,830
County Total			1,259,300	2,457,000	500,000	93,600	--	--	990	--	4,310,890
County Annual Average			52,470	102,380	20,830	3,900	--	--	40	--	179,620

Table 49 (continued)

County	Calendar Year	Project Year	Primary Environmental Corridor Subelement		Parkway Drive-Scenic Drive-Recreational Trail Subelement						Total (in Dollars)
					Parkway Drives		Recreational Trail		Scenic Drive	Interconnecting Urban Street	
			Land Acquisition[a] (in Dollars)	Operation and Maintenance[b] (in Dollars)	Construction[c] (in Dollars)	Operation and Maintenance[d] (in Dollars)	Construction[e] (in Dollars)	Operation and Maintenance[f] (in Dollars)	Signing and Marking[g] (in Dollars)	Signing and Marking[g] (in Dollars)	
Waukesha	1977	1	235,470	7,060	81,250	670	900	20	--	90	325,460
	1978	2	235,470	14,110	81,250	1,340	900	50	--	60	333,180
	1979	3	235,470	21,160	81,250	2,020	900	70	--	60	340,930
	1980	4	235,470	28,220	81,250	2,690	900	100	--	60	348,690
	1981	5	235,470	35,280	81,250	3,360	900	120	--	60	356,440
	1982	6	235,470	42,330	81,250	4,030	900	140	--	30	364,150
	1983	7	235,470	49,380	81,250	4,700	900	170	--	30	371,900
	1984	8	235,470	56,440	81,250	5,380	900	190	--	30	379,650
	1985	9	235,470	63,500	81,250	6,050	900	220	--	30	387,420
	1986	10	235,470	70,550	81,250	6,720	900	240	--	30	395,160
	1987	11	--	70,550	--	6,720	--	240	--	30	77,540
	1988	12	--	70,550	--	6,720	--	240	--	30	77,540
	1989	13	--	70,550	--	6,720	--	240	--	30	77,540
	1990	14	--	70,550	--	6,720	--	240	--	30	77,540
	1991	15	--	70,550	--	6,720	--	240	--	30	77,540
	1992	16	--	70,550	--	6,720	--	240	--	30	77,540
	1993	17	--	70,550	--	6,720	--	240	--	30	77,540
	1994	18	--	70,550	--	6,720	--	240	--	30	77,540
	1995	19	--	70,550	--	6,720	--	240	--	30	77,540
	1996	20	--	70,550	--	6,720	--	240	--	30	77,540
	1997	21	--	70,550	--	6,720	--	240	--	30	77,540
	1998	22	--	70,550	--	6,720	--	240	--	30	77,540
	1999	23	--	70,550	--	6,720	--	240	--	30	77,540
	2000	24	--	70,550	--	6,720	--	240	--	30	77,540
County Total			2,354,700	1,375,720	812,500	131,040	9,000	4,680	--	900	4,688,540
County Annual Average			98,110	57,320	33,850	5,460	380	200	--	38	195,350
Watershed Total			3,978,600	3,903,880	2,120,000	308,880	192,000	60,840	2,010	1,200	10,567,410
Annual Average			165,770	162,660	88,330	12,870	8,000	2,540	84	50	440,300

[a] *Assumes that 10 percent of the recommended 6.3 miles of primary environmental corridor land would be acquired in each of the first 10 years of plan implementation.*

[b] *Based on annual operation and maintenance cost of $50 per acre for corridor land.*

[c] *Assumes that 10 percent of the recommended 13.2 miles of new parkway drive would be constructed in each of the first 10 years of plan implementation.*

[d] *Based on annual operation and maintenance costs of $1,200 per mile for parkway drives.*

[e] *Assumes that 10 percent of the recommended 5.2 miles of new recreational trails would be constructed in each of the first 10 years of plan implementation.*

[f] *Based on annual operation and maintenance costs of $600 per mile for recreational trails.*

[g] *Assumes that a total of about two signs per mile at a cost of $30 per sign would be installed over a five year period and that about 10 percent of the signs would be replaced each year.*

Source: SEWRPC.

private and public recreational facilities. The remaining area lying in the corridors may then be placed in exclusive agricultural use districts or in large estate-type residential use districts, depending upon the limitations of the soils for utilization of onsite disposal systems.

Other Outdoor Recreational Sites: The remaining potential outdoor recreation sites identified during the watershed study and located outside the environmental corridors should be placed in exclusive agricultural, conservancy, or park districts so as to ensure preservation and availability for eventual public acquisition. It should be noted, however, that such zoning cannot be used in attempts to lower the land values of the parcels involved. Rather, such zoning should be used in an attempt to preserve the open character of the land, with public acquisition to occur at the determined fair market value within a reasonable period of time.

Floodlands: It is recommended that all counties, cities, villages, and towns within the watershed amend their zoning ordinances, as appropriate, to include special floodland regulations similar to those set forth in Appendix I of SEWRPC Planning Guide No. 5, Floodland and Shoreland Development Guide, as amended and improved through application in practice throughout the Southeastern Wisconsin Region. Such regulations, if properly adopted and enforced, will ensure the substantial maintenance in open uses of all undeveloped floodways and floodplains in the watershed. It should also be noted that such floodland regulations are required in addition to any basic zoning district regulations, such as agricultural districts, estate-type residential districts, park districts, and conservancy districts. Each county, city, and village in the watershed must, pursuant to Section 87.30 of the Wisconsin Statutes, formulate and adopt an effective and reasonable floodland zoning ordinance as soon as the necessary flood hazard data, such as that provided by the Menomonee River watershed study, become available. Failure to do so may result in the Wisconsin Department of Natural Resources acting to exercise state floodplain zoning powers, pursuant to Section 87.30 of the Wisconsin Statutes. The adoption of floodland regulations in those communities having substantial amounts of urban development already in the floodlands will require special attention and should be so constructed as to carry out the floodland management plan elements as discussed later in this chapter.

Property Tax Policies: One of the valid criticisms often leveled against the use of exclusive agricultural and conservancy districts, as well as of restrictive floodland regulations, is that in an urbanizing area the assessed valuation of the restrictively zoned land may be so high as to reasonably preclude the maintenance of the land in predominantly rural uses. In addition, the mill rate applied to the assessed valuation is often rapidly rising in developing communities due to increased demands for urban services and, in particular, for school services. This is particularly true where communities have allowed substantially unregulated land development to occur, resulting in extensive urban sprawl. It is this kind of development that would be avoided if the watershed land use plan is implemented.

Section 70.32 of the Wisconsin Statutes directs local assessors to assess real estate at the full market value which could ordinarily be obtained at a private sale. Where such open lands are adjacent to, or within, a rapidly urbanizing area, and particularly where poor land use regulations have permitted highly dispersed urban development, property tax assessments may reflect the public's sometimes exaggerated estimate of development potential. Even if the land is zoned for exclusive agricultural or conservancy use, the local assessor is allowed to, and commonly does, consider in the establishment of the market value of real property the reasonable probability of rezoning to permit more intensive use. Some lands zoned for agricultural or conservancy use realistically leave no potential for more intensive development, so that the market value and assessed value should both reflect that fact. Under present Wisconsin constitutional and statutory law, the most satisfactory way to relieve the owner of lands zoned for exclusive agricultural or conservancy use or for floodland use from the possibility of unrealistically high property assessment and resultant taxation where it exists is to remove the development potential. This may be accomplished in one of three ways:

1. The property owner may voluntarily grant an easement to a governmental unit, which easement would prohibit development for a period of at least 20 years;
2. The property owner may voluntarily place restrictive covenants upon the lands, which covenants would prohibit development and would be enforceable by a governmental unit in perpetuity or for some substantial time; or
3. A governmental unit may purchase the development rights.

All of these private or governmental actions will serve to permit and compel the local assessor to assess lands at their fair market value for agricultural, conservancy, and floodland uses rather than for potential urban uses. It is recommended that all cities, villages, and towns within the Menomonee River watershed instruct their assessors that such potential tax relief exists for individual property owners upon their voluntary sale or relinquishment of potential development rights, where, in fact, the possibility of rezoning and development exist.

It is recognized that all of the three above methods of removing the immediate development potential represent techniques largely untried in the Southeastern Wisconsin Region. At the present time, however, they represent the only satisfactory ways in which the inconsistencies between the Wisconsin taxing, land development, and open space reservation policies can at least partially be overcome.[10] It is clear that the entire problem represented by premature land development and the effects of property taxation needs extensive study within Wisconsin. Therefore, it is recommended that the Wisconsin Department of Local Affairs and Development take the lead in initiating a legislative study designed to probe the inconsistencies now existing between property taxation and land development policies in Wisconsin and recommend changes to the State Legislature. Such a study should be conducted in cooperation with the Wisconsin Departments of Revenue, Administration, and Natural Resources, as well as local and county governments and concerned citizen groups, such as the Wisconsin Taxpayers Alliance. The study should review efforts by other states to overcome this property tax and land development problem, in particular, the efforts being made in the States of New Jersey and California.[11]

[10] *For further discussion of this problem, see Chapter VI of SEWRPC Technical Report No. 6, Planning Law in Southeastern Wisconsin, 1976.*

[11] *The most recent attempts to resolve the property tax problems discussed in these paragraphs are a result of a fundamental change in the State Constitution as a result of being amended by Wisconsin voters in April 1974. The amendment allows the Legislature to revise the property tax laws to permit the taxing of agricultural and undeveloped land in a manner which need not be uniform with the taxation of other lands. In particular, Assembly Bill 1082, introduced into the Legislature in September 1975 by a special Legislative Council Committee, sought to permit the taxing of agricultural and conservancy lands at their current use value rather than their market value. As of yet, no legislation dealing with the revision of property tax laws has been acted upon by the Legislature.*

Greenway Tax Law Proposal: The problems relating to the deterioration and destruction of woodlands within the watershed were discussed in Chapter IX of Volume 1 of this report. In order to encourage private owners of woodlands to manage their stands on a balanced use and sustained yield basis and to provide an incentive for not changing the basic land use, it is recommended that the Wisconsin Department of Natural Resources take the lead in seeking the necessary state legislation to establish a new tax law program designed to provide for reduced property taxes on woodlands that are managed principally for aesthetic and scenic values, for wildlife conservancy, for limited production of forest products, and for watershed protection purposes.

This property tax law, which could be termed a "Greenway Tax Law," could be patterned after the existing Woodland Tax Law program. The principal feature of the proposed law would be to reduce the property tax rate on woodlands placed under the program in return for the property owners agreeing to undertake a sound woodland management program. Technical assistance in establishing the necessary management program could be provided by the Wisconsin Department of Natural Resources. The proposed law could also include a payment by the State to the local governments to help offset the reduced taxes. The law should also include a penalty clause for withdrawal of woodlands from the program.

Woodland and Wetland Management

The comprehensive Menomonee River watershed plan includes recommendations for the institution on a large scale of sound woodland and wetland management practices in an effort to conserve and improve these important resources. Implementation of this plan element will largely depend on action by private landowners of woodland and wetland areas. Technical and financial assistance is available to qualified private landowners in such efforts. The Wisconsin Department of Natural Resources, Division of Forestry and Recreation, and Division of Fish, Game, and Enforcement, and the University Extension Service will provide to all landowners, upon request and at no cost, technical advice on woodland and wetland management. Many woodland and wetland management techniques and measures such as tree planting, timber stand improvement, streambank protection, and establishment of wildlife cover, may be eligible for cost sharing through the Agricultural Conservation Program conducted by the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, in cooperation with local soil and water conservation districts, the U. S. Soil Conservation Service, the Wisconsin Department of Natural Resources, and the University Extension Service. Maximum use of such technical and financial assistance is essential to the implementation of sound management practices. Specific recommendations are discussed in the primary environmental corridor subelement section.

Land Acquisition

The recommended Menomonee River watershed plan places great emphasis upon the preservation, protection, and balanced use of the natural resource base, including the soils, surface and ground water, wetlands, woodlands, and wildlife habitat. Included in the plan are several recommendations for land acquisition to protect the natural resource base. It is important to recognize that, while zoning is an extremely important land use plan implementation tool, the use of the police power to achieve plan implementation has some significant limitations from an equitable public policy, if not a legal, point of view. Questions relating to the power inevitably arise when such power is extensively utilized for natural resource preservation objectives. Time and again attempts will be made by private landowners to convert their land to another use, often through the filling of significant wetland areas and the clearing of significant woodland areas, which filling and clearing usually destroy the primary natural resource value of the land. Such attempts at land use conversion inevitably arise, particularly in areas undergoing rapid urbanization. Thus, local plan commissions and governing bodies are constantly faced with applications to convert land uses; to fill low-lying wetland areas; and to, in effect, destroy the natural resource base. From a public policy point of view, therefore, it seems essential to purchase for permanent preservation as much of the primary environmental corridor lands in the watershed as possible, not only to assure the permanent preservation and protection of these important remaining elements of the sustaining and underlying natural resource base but also to lend equity to the situation where landowners are faced with no real alternative uses for significant parcels of land, parcels that may, properly or improperly, be increasing in assessed valuation as development proceeds in the surrounding area. Primary environmental corridor lands recommended to be purchased for permanent preservation are described under the primary environmental corridor subelement discussion.

Primary Environmental Corridor Subelement

The recommended primary environmental corridor subelement of the Menomonee River watershed plan will maintain the use of existing public and private outdoor recreation and related open space lands and will in addition involve public acquisition and public regulation of selective lands to protect the remaining high value portions of the primary environmental corridor. As shown on Map 50, most of this remaining high value corridor is located in several continuous segments along the main stem of the Menomonee River in Washington and Waukesha Counties. The primary environmental corridors contain about 64 percent of all perennial stream channel length in the watershed, about 64 percent of all remaining wetlands, about 40 percent of all remaining woodlands, and about 64 percent of all remaining wildlife habitat areas. To preserve these environmental corridors in essentially natural open uses the following recommendations are made.

Outdoor Recreation and Related Open Space Development: It is recommended that the existing public and private outdoor recreation and related open space lands in the Menomonee River watershed, which total about 5.2 square miles, or about 35 percent of the net primary environmental corridor, continue to be maintained in open space uses. It is further recommended that an additional 157 acres of snow skiing lands be provided in the watershed and that increased swimming and golfing facilities be provided in the urbanizing portions of the watershed. These needs can be met through use of the primary environmental corridor lands to be publicly acquired under the recommended primary environmental corridor subelement.

Woodlands, Wetlands, and Wildlife Habitat Management: It is recommended that sound management techniques be applied to all woodland, wetland, and wildlife habitat areas in general in the watershed. This applies to the woodland-wetland areas and wildlife habitat within the primary environmental corridor as well as to woodland-wetland and wildlife habitat located in the watershed but outside of the primary environmental corridors.

Primary Environmental Corridor Protection: The most important natural resource elements of the watershed—the best remaining woodlands, wetlands, and wildlife habitat as well as the surface waters, together with the associated floodlands and shorelands, and the best remaining potential park sites—have been found to occur within the primary environmental corridors of the watershed. Under this section of the primary environmental corridor subelement a total of 6.3 square miles of corridor are recommended for public acquisition along with 3.2 square miles of primary environmental corridor recommended to be protected by various land use controls.

Land Acquisition: It is recommended that Milwaukee County through its Park Commission acquire the remaining undeveloped primary environmental corridor along the Little Menomonee River in the City of Milwaukee, located between River Mile 5.19 and W. Brown Deer Road. In Washington County, it is recommended that the Washington County Park and Planning Commission acquire the undeveloped primary environmental corridor lands occurring in several continuous segments along the main stem of the Menomonee River in the Village of Germantown. In Waukesha County, it is recommended that the Waukesha County Park and Planning Commission acquire the undeveloped primary environmental corridor along the main stem of the Menomonee River in the Village of Butler, in several continuous segments along the main stem of the Menomonee River in the Village of Menomonee Falls, a portion of the Tamarack Swamp in the Village of Menomonee Falls, the Brookfield Swamp occurring in two portions in the City of Brookfield, and a portion of the Brookfield Swamp in the Town of Brookfield. No environmental corridor land acquisitions are recommended in Ozaukee County. A schedule of land acquisition costs for implementation of this portion of the primary environmental corridor subelement is set forth in Table 49. It should again be stressed that important relationships exist between these land acquisition recommendations, which are primarily for natural resource protection purposes, and the outdoor recreation and open space and woodlands, wetlands, and wildlife habitat sections of the primary environmental corridor subelement as well as the overall land use plan subelement and parkway drive-scenic drive-recreational trail subelement of the land use plan.

In the interest of implementing the land acquisition portion of the primary environmental corridor subelement, particularly in Washington and Waukesha Counties, it may be feasible to involve the local units of governments in the acquisition of primary environmental corridor lands. Several communities have initiated corridor acquisition programs and already own segments of the recommended environmental corridor. These communities may wish to continue their acquisition programs separately or with financial assistance from their respective counties, or they may desire to donate their holdings to their county as was done in Milwaukee County in 1937.

Land Use Controls: It is recommended that all primary environmental corridor protected by existing land use controls consistent with corridor protection continue to be so protected. These lands are distributed as follows: in the City of Milwaukee along the main stem of the Menomonee River and the Little Menomonee River; in the City of Mequon along the Little Menomonee River; in the City of Brookfield along the Butler Ditch, the Underwood Creek, the South Branch of Underwood Creek, and the Brookfield Swamp; in the Village of Elm Grove along the Underwood Creek; and in the Village of Menomonee Falls along the Butler Ditch. It is further recommended that all remaining primary environmental corridor be protected through application of new land use controls. These corridor lands are distributed in the following manner: in the City of Greenfield along Honey Creek; in the City of Milwaukee along the main stem of the Menomonee River and the Honey Creek; in the City of Wauwatosa along the main stem of the Menomonee River, the Underwood Creek, and the Honey Creek; in the City of West Allis along the Honey Creek and the South Branch of Underwood Creek; in the City of Mequon primarily along the Little Menomonee River; in the Village of Germantown located throughout the Village; in the Town of Germantown along the North Branch of the Menomonee River; in the City of Brookfield primarily located along the Butler Ditch, the Underwood Creek, the South Branch of Underwood Creek, and the Brookfield Swamp; along the main stem of the Menomonee River in the Village of Butler; in the Village of Elm Grove primarily along the Underwood Creek; and in the Village of Menomonee Falls along the Butler Ditch.

Land use controls can be of the following types: agricultural, floodland, shoreland, conservancy, and very low-density residential zoning. This zoning should encompass all of the riverine areas lying within the primary environmental corridor.

Parkway Drive-Scenic Drive-
Recreational Trail Subelement

Pleasure driving constitutes a popular outdoor recreational activity in the Menomonee River watershed. Therefore, this subelement is included as an integral part of the land use plan element. As shown on Map 50, the recommended parkway drive-scenic drive-recreational trail system would extend from and be generally similar to the extensive parkway system that already exists in the Milwaukee County portion of the watershed, and would consist of 56.8 miles of environmental corridor-oriented parkway pleasure drives, scenic pleasure drives, recreational trail, and interconnecting urban streets.

Parkway Drives: It is recommended that the Milwaukee County Park Commission continue to maintain the existing 14.0 miles of parkway pleasure drive along the Menomonee River, Little Menomonee River, Underwood Creek, and the South Branch of Underwood Creek, and that it construct and maintain an additional 3.6 miles of new parkway pleasure drive located along the Menomonee River. It is recommended that the Washington County Park and Planning Commission construct and maintain 4.0 miles of new parkway pleasure drive located along the Menomonee River in the Village of Germantown. It is recommended that the Waukesha County Park and Planning Commission maintain the existing 2.0 miles of parkway pleasure drive along the Menomonee River and the Tamarack Swamp in the Village of Menomonee Falls and construct and maintain 5.6 miles of new parkway pleasure drive located along the Menomonee River and the Tamarack Swamp in the Village of Menomonee Falls. A cost schedule for construction and maintenance of the proposed parkway pleasure drive system is shown in Table 49.

Scenic Drives: It is recommended that the County Highway Committees of Ozaukee and Washington Counties, together with the Wisconsin Department of Transportation, coordinate the establishment over existing state, county, and local streets and highways of the recommended system of Menomonee River scenic drives. It is anticipated that the establishment of this scenic drive system will consist primarily of the design, preparation, and placement of appropriate signs identifying the scenic drive route along its total 13.2-mile length, an effort similar in nature to the marking of the existing Kettle Moraine Scenic Drive. A cost schedule for signing and marking the scenic drive system in the Menomonee River watershed over the next 24 years is shown in Table 49.

Recreational Trails: It is recommended that the Milwaukee County Park Commission continue to maintain the existing 2.3 miles of recreational trail along the Little Menomonee River and construct and maintain an additional 4.3 miles of new recreational trail along the Little Menomonee River, 0.4 mile along the Underwood Creek, and 0.1 mile along the South Branch of Underwood Creek. It is recommended that the Waukesha County Park and Planning Commission construct and maintain 0.4 mile of new recreational trail located along the South Branch of Underwood Creek. A cost schedule for constructing and maintaining the recreational trail system is shown in Table 49.

Interconnecting Urban Streets: It is recommended that the Transportation and Public Works Committee of Milwaukee County and the Highway Committee of Waukesha County, together with the Wisconsin Department of Transportation, consider the incorporation of the 6.9 miles of existing urban streets interconnecting the watershed parkway drive system into the total parkway drive-scenic drive-recreational trail system. This would consist primarily of the design, preparation, and placement of appropriate signs along the 6.9 mile route. A cost schedule for signing and marking the interconnecting urban streets is shown in Table 49.

FLOODLAND MANAGEMENT PLAN ELEMENT IMPLEMENTATION

The major floodland management recommendation contained in the Menomonee River watershed plan is the institution of sound floodland zoning regulations throughout the watershed and the acquisition, for public park and open space use, of selected undeveloped floodlands along the Menomonee River and its major tributaries. The recommended floodland management plan element for the Menomonee River watershed also includes the application of structural measures on a community-by-community basis for those riverine areas experiencing the most severe flood problems as well as nonstructural floodland management measures designed to minimize or eliminate existing flood problems. The floodland management plan element is divided into the following subelements: land use controls, structural measures for flood damage abatement, bridge replacement, flood insurance, lending institution and realtor policies, streamflow recordation, miscellaneous measures for the industrial valley, and maintenance of stream channels and hydraulic structure waterway openings. The recommended implementation actions discussed under this plan element are summarized in Table 48 and a schedule of capital and operation and maintenance costs for this plan element are set forth in Table 50.

Land Use Controls Subelement

Floodland Regulations: It is recommended that the Cities of Brookfield, Greenfield, Mequon, Milwaukee, Wauwatosa, and West Allis and the Villages of Butler, Elm Grove, Germantown, and Menomonee Falls modify existing floodland and related regulations or prepare new floodland regulations based upon the flood hazard data and the floodland management concepts and recommendations set forth in this report. It is further recommended that, in addition to meeting minimum hydrologic-hydraulic standards established by the Wisconsin Floodplain Management Program, the floodland recommendations complement the recommended land use plan element. It is also recommended that floodland and related regulations be used to provide interim control over corridor lands recommended for public acquisition.

It is recommended that one of the two following basic types of floodland and floodland-related measures be instituted by local units of government on a reach by reach basis in the watershed:

1. In those areas of the watershed where the floodlands lying within the 100-year recurrence interval flood hazard zone under year 2000 plan conditions are presently undeveloped and not

committed to urban development, all future incompatible urban development be discouraged through appropriate floodland and floodland-related land use regulations.

2. In those areas of the watershed where the floodlands are already in some form of urban development, or committed to such development, the floodland and floodland-related land use regulations should be designed so as to accommodate existing development, to preserve sufficient conveyance capacity for the 100-year flood flow through delineation and preservation of a floodway, and require the floodproofing of all new urban development committed in the floodplain fringe.

It should be noted that some communities lying partially within the Menomonee River watershed and not recommended to adopt floodland regulations under the Menomonee River watershed plan may be required to adopt floodland regulations for streams outside of the Menomonee River watershed.

Land Use Controls Outside of the Floodlands: It is recommended that all counties, cities, villages, and towns within the Menomonee River watershed adopt land use controls outside of the floodlands, as needed to achieve the recommended watershed land use plan for the year 2000. Such land use controls may take the form of or be incorporated into zoning, land subdivision, sanitary, and building ordinances. Land use controls outside of the floodlands should be viewed as an important floodland management measure for the watershed.

Structural Measures for Flood Damage Abatement Subelement

Village of Elm Grove: It is recommended that the Village of Elm Grove cooperatively with the City of Brookfield extend to the Underwood Sewer Commission (a cooperative contract commission established under Section 66.30 of the Wisconsin Statutes by contract between the City of Brookfield and the Village of Elm Grove for the purposes of constructing, operating, and maintaining a sanitary intercepting sewer along Underwood Creek) the authority to deal with the storm and floodwater problems affecting the two communities. In particular, it is recommended that the Underwood Sewer Commission, given bonding powers for the purpose of acquiring, developing, and equipping land, buildings, and facilities for areawide flood control projects, be authorized to implement the following flood damage abatement measures for the Village of Elm Grove and the City of Brookfield.

Table 50

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE FLOODLAND MANAGEMENT PLAN ELEMENT OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED BY COUNTY AND YEAR: 1976-2000

			Channel Modifications		Detention Storage				Stream Gaging Network			
County	Calendar Year	Project Year	Construction (in Dollars)	Operation and Maintenance (in Dollars)	Construction (in Dollars)	Operation and Maintenance (in Dollars)	Structure Floodproofing and Removal (in Dollars)	Bridge Modification for Flood Control Purposes (in Dollars)	Operation and Maintenance of Continuous Recorder Gages[a] (in Dollars)	Installation of Staff or Crest Stage Gages[b] (in Dollars)	Industrial Valley Measures[c] (in Dollars)	Total (in Dollars)
Milwaukee	1977	1	572,000	1,000	--	--	752,500	--	--	--	162,600	1,488,100
	1978	2	572,000	2,100	--	--	752,500	--	3,200	--	162,600	1,492,400
	1979	3	572,000	3,100	--	--	752,500	--	3,200	--	162,600	1,493,400
	1980	4	572,000	4,200	--	--	752,500	--	3,200	--	162,600	1,494,500
	1981	5	572,000	5,200	--	--	752,500	--	3,200	--	162,600	1,495,500
	1982	6	--	5,200	--	--	--	--	3,200	--	--	8,400
	1983	7	--	5,200	--	--	--	--	3,200	--	--	8,400
	1984	8	--	5,200	--	--	--	--	3,200	--	--	8,400
	1985	9	--	5,200	--	--	--	--	3,200	--	--	8,400
	1986	10	--	5,200	--	--	--	--	3,200	--	--	8,400
	1987	11	--	5,200	--	--	--	--	3,200	--	--	8,400
	1988	12	--	5,200	--	--	--	--	3,200	--	--	8,400
	1989	13	--	5,200	--	--	--	--	3,200	--	--	8,400
	1990	14	--	5,200	--	--	--	--	3,200	--	--	8,400
	1991	15	--	5,200	--	--	--	--	3,200	--	--	8,400
	1992	16	--	5,200	--	--	--	--	3,200	--	--	8,400
	1993	17	--	5,200	--	--	--	--	3,200	--	--	8,400
	1994	18	--	5,200	--	--	--	--	3,200	--	--	8,400
	1995	19	--	5,200	--	--	--	--	3,200	--	--	8,400
	1996	20	--	5,200	--	--	--	--	3,200	--	--	8,400
	1997	21	--	5,200	--	--	--	--	3,200	--	--	8,400
	1998	22	--	5,200	--	--	--	--	3,200	--	--	8,400
	1999	23	--	5,200	--	--	--	--	3,200	--	--	8,400
	2000	24	--	5,200	--	--	--	--	3,200	--	--	8,400
County Total			2,860,000	114,400	--	--	3,762,600	--	73,600	--	813,000	7,623,600
County Annual Average			119,200	4,800	--	--	156,800	--	3,100	--	33,900	317,700

Table 50 (continued)

County	Calendar Year	Project Year	Channel Modifications		Detention Storage		Structure Floodproofing and Removal (in Dollars)	Bridge Modification for Flood Control Purposes (in Dollars)	Stream Gaging Network	Installation of Staff or Crest Stage Gages[b] (in Dollars)	Industrial Valley Measures[c] (in Dollars)	Total (in Dollars)
			Construction (in Dollars)	Operation and Maintenance (in Dollars)	Construction (in Dollars)	Operation and Maintenance (in Dollars)			Operation and Maintenance of Continuous Recorder Gages[a] (in Dollars)			
Ozaukee	1977	1	--	--	--	--	2,400	--	--	50	--	2,450
	1978	2	--	--	--	--	2,400	--	--	--	--	2,400
	1979	3	--	--	--	--	2,400	--	--	--	--	2,400
	1980	4	--	--	--	--	2,400	--	--	--	--	2,400
	1981	5	--	--	--	--	2,400	--	--	--	--	2,400
	1982	6	--	--	--	--	--	--	--	--	--	--
	1983	7	--	--	--	--	--	--	--	--	--	--
	1984	8	--	--	--	--	--	--	--	--	--	--
	1985	9	--	--	--	--	--	--	--	--	--	--
	1986	10	--	--	--	--	--	--	--	--	--	--
	1987	11	--	--	--	--	--	--	--	--	--	--
	1988	12	--	--	--	--	--	--	--	--	--	--
	1989	13	--	--	--	--	--	--	--	--	--	--
	1990	14	--	--	--	--	--	--	--	--	--	--
	1991	15	--	--	--	--	--	--	--	--	--	--
	1992	16	--	--	--	--	--	--	--	--	--	--
	1993	17	--	--	--	--	--	--	--	--	--	--
	1994	18	--	--	--	--	--	--	--	--	--	--
	1995	19	--	--	--	--	--	--	--	--	--	--
	1996	20	--	--	--	--	--	--	--	--	--	--
	1997	21	--	--	--	--	--	--	--	--	--	--
	1998	22	--	--	--	--	--	--	--	--	--	--
	1999	23	--	--	--	--	--	--	--	--	--	--
	2000	24	--	--	--	--	--	--	--	--	--	--
County Total			--	--	--	--	12,000	--	--	50	--	12,050
County Annual Average			--	--	--	--	500	--	--	2	--	502

County	Calendar Year	Project Year	Channel Modifications		Detention Storage		Structure Floodproofing and Removal (in Dollars)	Bridge Modification for Flood Control Purposes (in Dollars)	Stream Gaging Network	Installation of Staff or Crest Stage Gages[b] (in Dollars)	Industrial Valley Measures[c] (in Dollars)	Total (in Dollars)
			Construction (in Dollars)	Operation and Maintenance (in Dollars)	Construction (in Dollars)	Operation and Maintenance (in Dollars)			Operation and Maintenance of Continuous Recorder Gages[a] (in Dollars)			
Washington	1977	1	--	--	--	--	--	--	--	100	--	100
	1978	2	--	--	--	--	--	--	--	--	--	--
	1979	3	--	--	--	--	--	--	--	--	--	--
	1980	4	--	--	--	--	--	--	--	--	--	--
	1981	5	--	--	--	--	--	--	--	--	--	--
	1982	6	--	--	--	--	--	--	--	--	--	--
	1983	7	--	--	--	--	--	--	--	--	--	--
	1984	8	--	--	--	--	--	--	--	--	--	--
	1985	9	--	--	--	--	--	--	--	--	--	--
	1986	10	--	--	--	--	--	--	--	--	--	--
	1987	11	--	--	--	--	--	--	--	--	--	--
	1988	12	--	--	--	--	--	--	--	--	--	--
	1989	13	--	--	--	--	--	--	--	--	--	--
	1990	14	--	--	--	--	--	--	--	--	--	--
	1991	15	--	--	--	--	--	--	--	--	--	--
	1992	16	--	--	--	--	--	--	--	--	--	--
	1993	17	--	--	--	--	--	--	--	--	--	--
	1994	18	--	--	--	--	--	--	--	--	--	--
	1995	19	--	--	--	--	--	--	--	--	--	--
	1996	20	--	--	--	--	--	--	--	--	--	--
	1997	21	--	--	--	--	--	--	--	--	--	--
	1998	22	--	--	--	--	--	--	--	--	--	--
	1999	23	--	--	--	--	--	--	--	--	--	--
	2000	24	--	--	--	--	--	--	--	--	--	--
County Total			--	--	--	--	--	--	--	100	--	100
County Annual Average			--	--	--	--	--	--	--	4	--	4

Table 50 (continued)

County	Calendar Year	Project Year	Channel Modifications: Construction (in Dollars)	Channel Modifications: Operation and Maintenance (in Dollars)	Detention Storage: Construction (in Dollars)	Detention Storage: Operation and Maintenance (in Dollars)	Structure Floodproofing and Removal (in Dollars)	Bridge Modification for Flood Control Purposes (in Dollars)	Stream Gaging Network: Operation and Maintenance of Continuous Recorder Gages[a] (in Dollars)	Installation of Staff or Crest Stage Gages[b] (in Dollars)	Industrial Valley Measures[c] (in Dollars)	Total (in Dollars)
Waukesha	1977	1	900,500	1,300	126,000	1,200	196,600	42,000	--	300	--	1,267,900
	1978	2	900,500	2,600	126,000	2,500	196,600	42,000	3,200	--	--	1,273,400
	1979	3	900,500	3,900	126,000	3,700	196,600	42,000	3,200	--	--	1,275,900
	1980	4	900,500	5,200	126,000	5,000	196,600	42,000	3,200	--	--	1,278,500
	1981	5	900,500	6,500	126,000	6,200	196,600	42,000	3,200	--	--	1,281,000
	1982	6	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1983	7	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1984	8	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1985	9	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1986	10	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1987	11	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1988	12	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1989	13	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1990	14	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1991	15	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1992	16	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1993	17	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1994	18	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1995	19	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1996	20	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1997	21	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1998	22	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	1999	23	--	6,500	--	6,200	--	--	3,200	--	--	15,900
	2000	24	--	6,500	--	6,200	--	--	3,200	--	--	15,900
County Total			4,502,400	143,000	630,100	136,400	983,000	210,000	73,600	300	--	6,678,800
County Annual Average			187,600	6,000	26,300	5,700	41,000	8,800	3,100	12	--	278,300
Watershed Total			7,362,400	257,400	630,100	136,400	4,757,600	210,000	147,200	450	813,000	14,314,550
Annual Average			306,800	10,700	26,300	5,700	198,200	8,800	6,100	18	33,900	596,400

[a] *Two continuous stage recorder installations each having a total operation and maintenance cost of $3,200 per year.*

[c] *Assumes a two foot increase in the height of 0.70 mile of earthen dike along the Menomonee River in the vicinity of the Chicago, Milwaukee, St. Paul, and Pacific Railroad property at $70 per lineal foot; a four foot increase in the height of 0.24 mile of floodwalls along the east bank of the Menomonee River between the East-West Freeway and the W. Wisconsin Avenue Viaduct at $140 per lineal foot; a four foot increase in the height of 0.16 mile of floodwall along the east bank of the Menomonee River between the W. Wisconsin Avenue Viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge at River Mile 4.24 at $140 per lineal foot; and a four foot increase in the height of 0.35 mile of floodwall along parts of both banks of the Menomonee River between the railroad bridge and N. 45th Street at $140 per lineal foot. The estimated capital cost of the total 1.45 miles of dike-floodwall extension is $813,000.*

[b] *Nine staff or crest stage gages—one in the City of Mequon in Ozaukee County, two in the Village of Germantown in Washington County, and three in the City of Brookfield and one in the Village of Elm Grove and two in the Village of Menomonee Falls in Waukesha County—at $50 per installation.*

Source: SEWRPC.

1. Construct and maintain a 215 acre-foot flood detention reservoir on Dousman Ditch in the City of Brookfield as shown on Map 51. The cost of the proposed reservoir should be proportioned between the Village of Elm Grove and the City of Brookfield on the basis of the flood control benefits which would be realized.

2. Replace the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge over Underwood Creek near Pilgrim Road and Indian Creek Parkway.

It is further recommended that the Underwood Sewer Commission seek financial and technical assistance in the implementation of the above recommendations. Such financial and technical assistance may come from various federal agencies, including the Corps of Engineers and the Soil Conservation Service.

It is recommended that up to about 187 residential structures along Underwood Creek within the Village be adequately floodproofed and that one structure be removed. It also is recommended that the Village include in its zoning, building, housing, subdivision, and sanitary ordinances, as appropriate, regulations dealing with structure floodproofing. It is possible and generally practicable for property owners, as individuals, to make certain structural adjustments to existing private properties in order to significantly reduce potential flood damages. Extensive floodproofing should be applied, however, only under the guidance of a registered engineer who has carefully inspected the building and its contents and has evaluated the flood threat.

A schedule of capital costs for implementing this portion of the structural measures for flood damage abatement subelement is set forth in Table 51.

Table 51

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE PRIMARILY STRUCTURAL FLOODLAND MANAGEMENT PLAN SUBELEMENT OF THE RECOMMENDED MENOMONEE RIVER WATERSHED PLAN FOR THE VILLAGE OF ELM GROVE BY YEAR: 1977-2000

Calendar Year	Project Year	Detention Reservoir on Dousman Ditch		Floodproofing and Removal Along Underwood Creek (in Dollars)	Total (in Dollars)
		Construction (in Dollars)	Operation and Maintenance (in Dollars)		
1977	1	102,800	1,000	116,600	220,400
1978	2	102,800	2,000	116,600	221,400
1979	3	102,800	3,000	116,600	222,400
1980	4	102,800	4,000	116,600	223,400
1981	5	102,800	5,100[a]	116,600	224,500
1982	6	--	5,100	--	5,100
1983	7	--	5,100	--	5,100
1984	8	--	5,100	--	5,100
1985	9	--	5,100	--	5,100
1986	10	--	5,100	--	5,100
1987	11	--	5,100	--	5,100
1988	12	--	5,100	--	5,100
1989	13	--	5,100	--	5,100
1990	14	--	5,100	--	5,100
1991	15	--	5,100	--	5,100
1992	16	--	5,100	--	5,100
1993	17	--	5,100	--	5,100
1994	18	--	5,100	--	5,100
1995	19	--	5,100	--	5,100
1996	20	--	5,100	--	5,100
1997	21	--	5,100	--	5,100
1998	22	--	5,100	--	5,100
1999	23	--	5,100	--	5,100
2000	24	--	5,100	--	5,100
Total		514,200[b]	112,000	583,000	1,209,200
24-Year Annual Average		21,400	4,700	24,300	50,400

[a] *That portion of the full $6,200 annual operation and maintenance cost that would be assumed by Elm Grove.*

[b] *That portion of the full $630,100 capital cost that would be assumed by Elm Grove.*

Source: SEWRPC.

City of Brookfield: As discussed in the section preceding, it is recommended that the Underwood Sewer Commission be given the authority to implement the following recommendations dealing with flood damage abatement in the City of Brookfield:

1. Construct and maintain a 215 acre-foot detention storage reservoir on Dousman Ditch in the City of Brookfield, with the cost to be divided proportionately between the City of Brookfield and the Village of Elm Grove.
2. Replace the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge over Underwood Creek near Pilgrim Road and Indian Creek Parkway.

It is further recommended that the Underwood Sewer Commission investigate all possible sources of financial and technical assistance to aid in the implementation of the above recommendations.

It also is recommended that the Waukesha County Park and Planning Commission in conjunction with the City of Brookfield establish a program for the eventual acquisition and removal by the City or County of about seven structures along the Underwood Creek reach bounded at the upstream end by the Chicago, Milwaukee, St. Paul, and Pacific Railroad and at the downstream end by W. North Avenue.

It also is recommended that the City include in its zoning, building, housing, subdivision, and sanitary ordinances, as appropriate, regulations pertaining to structure floodproofing. It is further recommended that up to about 65 structures along Underwood Creek downstream of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and 20 structures along Butler Ditch be floodproofed by their owners, under the supervision of a registered engineer.

A schedule of capital costs for implementing this portion of the structural measures for flood damage abatement subelement is summarized in Table 52.

City of Wauwatosa: It is recommended that the Metropolitan Sewerage Commission of the County of Milwaukee construct and maintain 1.65 miles of major channelization along the Menomonee River from N. 45th Street in the City of Milwaukee to the N. 70th Street bridge in the City of Wauwatosa. This channelization would be supplemented with low dikes and floodwalls along the Wauwatosa portion of the affected reach. It is further recommended that the Metropolitan Sewerage Commission investigate all available sources of financial and technical assistance, including for instance, the U. S. Army Corps of Engineers.

Table 52

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE PRIMARILY STRUCTURAL FLOODLAND MANAGEMENT PLAN SUBELEMENT OF THE RECOMMENDED MENOMONEE RIVER WATERSHED PLAN FOR THE CITY OF BROOKFIELD BY YEAR: 1977-2000

Calendar Year	Project Year	Detention Reservoir on Dousman Ditch: Construction (in Dollars)	Detention Reservoir on Dousman Ditch: Operation and Maintenance (in Dollars)	Replace Bridge on Underwood Creek (in Dollars)	Floodproofing and Removal Along Underwood Creek (in Dollars)	Floodproofing Along Butler Ditch (in Dollars)	Total (in Dollars)
1977	1	23,200	200	42,000	78,700	1,300	145,400
1978	2	23,200	400	42,000	78,700	1,300	145,600
1979	3	23,200	700	42,000	78,700	1,300	145,900
1980	4	23,200	900	42,000	78,700	1,300	146,100
1981	5	23,200	1,100	42,000	78,700	1,300	146,400
1982	6	--	1,100	--	--	--	1,100
1983	7	--	1,100	--	--	--	1,100
1984	8	--	1,100	--	--	--	1,100
1985	9	--	1,100	--	--	--	1,100
1986	10	--	1,100	--	--	--	1,100
1987	11	--	1,100	--	--	--	1,100
1988	12	--	1,100	--	--	--	1,100
1989	13	--	1,100	--	--	--	1,100
1990	14	--	1,100	--	--	--	1,100
1991	15	--	1,100	--	--	--	1,100
1992	16	--	1,100	--	--	--	1,100
1993	17	--	1,100	--	--	--	1,100
1994	18	--	1,100	--	--	--	1,100
1995	19	--	1,100	--	--	--	1,100
1996	20	--	1,100	--	--	--	1,100
1997	21	--	1,100	--	--	--	1,100
1998	22	--	1,100	--	--	--	1,100
1999	23	--	1,100	--	--	--	1,100
2000	24	--	1,100	--	--	--	1,100
Total		115,800	24,200	210,000	393,600	6,400	750,300
24-Year Annual Average		4,800	1,000	8,800	16,400	300	31,300

Source: SEWRPC.

It is recommended that the City of Wauwatosa assume responsibility for the capital cost and operation and maintenance costs of the stormwater pumping stations and backwater gates and other stormwater control facilities needed to supplement the dikes and floodwalls.

It is recommended that the Milwaukee County Park Commission in conjunction with the City of Wauwatosa establish a program for the eventual acquisition and removal by the City or County of about nine structures along the Menomonee River between Harwood Avenue and W. Hampton Avenue. Furthermore, it is recommended that the City of Wauwatosa establish a program for the eventual acquisition and removal by the City of about 61 structures along the Menomonee River between Hawley Road and the N. 70th Street bridge, a program that will provide for the mitigation of flood damages as well as the expansion of Hart Park.

It is recommended that the City of Wauwatosa include in its zoning, building, housing, subdivision, and sanitary ordinances, as appropriate, regulations pertaining to structure floodproofing. It is further recommended that up to about 93 structures along the Menomonee River between N. 70th Street and Harwood Avenue, up to about 203 structures along the Menomonee River between Harwood Avenue and W. Hampton Avenue, up to about 13 structures along Honey Creek between the Menomonee River and W. Wisconsin Avenue, and up to about 56 structures along Underwood Creek between the Menomonee River and the Zoo Freeway be floodproofed by their owners under supervision of a registered engineer.

A schedule of capital costs for implementing this portion of the structural measures for flood damage abatement subelement is set forth in Table 53.

Table 53

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE PRIMARILY STRUCTURAL FLOODLAND MANAGEMENT PLAN SUBELEMENT OF THE RECOMMENDED MENOMONEE RIVER WATERSHED PLAN FOR THE CITY OF WAUWATOSA BY YEAR: 1977-2000

Calendar Year	Project Year	Channelization—Dikes and Floodwalls on Menomonee River: Construction (in Dollars)	Channelization—Dikes and Floodwalls on Menomonee River: Operation and Maintenance (in Dollars)	Structure Floodproofing and Removal Along Menomonee River Between Harwood Avenue and N. 70th Street (in Dollars)	Structure Floodproofing and Removal Along Menomonee River Upstream of Harwood Avenue (in Dollars)	Structure Floodproofing Along Underwood Creek (in Dollars)	Structure Floodproofing Along Honey Creek (in Dollars)	Total (in Dollars)
1977	1	572,000	1,000	540,600	188,500	6,000	700	1,308,800
1978	2	572,000	2,100	540,600	188,500	6,000	700	1,309,900
1979	3	572,000	3,100	540,600	188,500	6,000	700	1,310,900
1980	4	572,000	4,200	540,600	188,500	6,000	700	1,312,000
1981	5	572,000	5,200	540,600	188,500	6,000	700	1,313,000
1982	6	--	5,200	--	--	--	--	5,200
1983	7	--	5,200	--	--	--	--	5,200
1984	8	--	5,200	--	--	--	--	5,200
1985	9	--	5,200	--	--	--	--	5,200
1986	10	--	5,200	--	--	--	--	5,200
1987	11	--	5,200	--	--	--	--	5,200
1988	12	--	5,200	--	--	--	--	5,200
1989	13	--	5,200	--	--	--	--	5,200
1990	14	--	5,200	--	--	--	--	5,200
1991	15	--	5,200	--	--	--	--	5,200
1992	16	--	5,200	--	--	--	--	5,200
1993	17	--	5,200	--	--	--	--	5,200
1994	18	--	5,200	--	--	--	--	5,200
1995	19	--	5,200	--	--	--	--	5,200
1996	20	--	5,200	--	--	--	--	5,200
1997	21	--	5,200	--	--	--	--	5,200
1998	22	--	5,200	--	--	--	--	5,200
1999	23	--	5,200	--	--	--	--	5,200
2000	24	--	5,200	--	--	--	--	5,200
Total		2,860,000	114,400	2,703,200	942,700	29,800	3,300	6,653,400
24-Year Annual Average		119,200	4,800	112,600	39,300	1,200	100	277,200

Source: SEWRPC.

City of Mequon: It is recommended that the City of Mequon include in its zoning, building, housing, subdivision, and sanitary ordinances, as appropriate, regulations governing the floodproofing of structures. It is further recommended that up to about 19 structures along the Little Menomonee River be floodproofed by their owners under the supervision of a registered engineer.

City of Milwaukee: It is recommended that the City of Milwaukee incorporate into its zoning, building, housing, subdivision, and sanitary ordinances, as appropriate, regulations governing the floodproofing of structures. It is further recommended that up to about 69 structures along the Menomonee River between N. 45th Street and Hawley Road be floodproofed by their owners under the supervision of a registered engineer.

Village of Menomonee Falls: It is recommended that the Village of Menomonee Falls construct and maintain 4.00 miles of major channelization along the Menomonee River between the Washington-Waukesha County line and the Menomonee Falls dam and between Arthur Avenue and the Milwaukee-Waukesha County line. It is further recommended that the Village of Menomonee Falls construct and maintain 2.97 miles of major channelization along Lilly Creek between its confluence with the Menomonee River and Silver Spring Road.

A schedule of capital costs for implementing this portion of the structural measures for flood damage abatement subelement is set forth in Table 54.

Concluding Remarks—Structure Removal: The foregoing discussion summarizes on a community-by-community basis the flood damage abatement measures recommended in the Menomonee River watershed plan. In some instances these measures include structure removal where structure floodproofing is inappropriate or impractical, or where the land involved is recommended to be reused for a public purpose. The structure removal

Table 54

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE PRIMARILY STRUCTURAL FLOODLAND MANAGEMENT PLAN SUBELEMENT OF THE RECOMMENDED MENOMONEE RIVER WATERSHED PLAN FOR THE VILLAGE OF MENOMONEE FALLS BY YEAR: 1977-2000

Calendar Year	Project Year	Major Channelization on Menomonee River		Major Channelization on Lilly Creek		Total (in Dollars)
		Construction (in Dollars)	Operation and Maintenance (in Dollars)	Construction (in Dollars)	Operation and Maintenance (in Dollars)	
1977	1	415,700	900	484,800	400	901,800
1978	2	415,700	1,700	484,800	900	903,100
1979	3	415,700	2,600	484,800	1,300	904,400
1980	4	415,700	3,400	484,800	1,800	905,700
1981	5	415,700	4,300	484,800	2,200	907,000
1982	6	--	4,300	--	2,200	6,500
1983	7	--	4,300	--	2,200	6,500
1984	8	--	4,300	--	2,200	6,500
1985	9	--	4,300	--	2,200	6,500
1986	10	--	4,300	--	2,200	6,500
1987	11	--	4,300	--	2,200	6,500
1988	12	--	4,300	--	2,200	6,500
1989	13	--	4,300	--	2,200	6,500
1990	14	--	4,300	--	2,200	6,500
1991	15	--	4,300	--	2,200	6,500
1992	16	--	4,300	--	2,200	6,500
1993	17	--	4,300	--	2,200	6,500
1994	18	--	4,300	--	2,200	6,500
1995	19	--	4,300	--	2,200	6,500
1996	20	--	4,300	--	2,200	6,500
1997	21	--	4,300	--	2,200	6,500
1998	22	--	4,300	--	2,200	6,500
1999	23	--	4,300	--	2,200	6,500
2000	24	--	4,300	--	2,200	6,500
Total		2,078,600	94,600	2,423,800	48,400	4,645,400
24-Year Annual Average		86,600	3,900	101,000	2,000	193,500

Source: SEWRPC.

recommendations are of two basic types. The first type consists of structure removal from a relatively large area only part of which may be actually floodprone to the extent requiring structure removal, which area can then be used for the development of a public park or parkway. The second type consists of structure removal from small, scattered floodprone sites, the size and scattered nature of the sites precluding redevelopment for public park purposes for practical reasons.

In the former case, it is clear that there are at least two aid programs—the state Outdoor Recreation Act Program (ORAP) and the federal Land and Water Conservation Program (LAWCON)—directly applicable to implementation of floodland evacuation recommendations. With respect to the plan recommendation that the City of Wauwatosa acquire and remove nearly 50 homes from the floodplain adjacent to existing Hart Park and utilize the cleared land for the expansion of that park, for example, it would be possible for the City to apply for and—assuming the availability of sufficient state and federal funds—receive state and federal grants-in-aid for the acquisition and removal of the structures involved and the conversion of the sites acquired to public park and open space use. This funding eligibility would exist even if the structures involved were acquired on an ad hoc, individual site-by-site basis over a relatively long period of time, provided that the implementing agency prepares and submits to the approving state and federal agencies, in this case the Wisconsin Department of Natural Resources and the U. S. Department of the Interior, Bureau of Outdoor Recreation, a proper project application that includes the entire area proposed to be acquired and ultimately converted to park and open space use.

In the case of scattered site acquisition, implementation with state and federal assistance may be somewhat more difficult to attain. There are no existing categorical state and federal aid programs that are designed to be used to acquire scattered floodprone structures where the intent is not to reuse the land for public park and open space purposes, but to return the land to private open space use after "writing off" some of the acquisition and clearance costs. The only federal grant-in-aid program that, as a practical matter, could be used to assist local communities in the Menomonee River watershed in acquiring and removing such scattered floodprone structures is the community development block grant program administered by the U. S. Department of Housing and Urban Development. Under this program, cities in excess of 50,000 population, including Milwaukee and Wauwatosa in the watershed, are entitled to receive annually substantial amounts of block grant funds for a wide range of community development purposes, including urban renewal and neighborhood improvement, urban beautification, and park land acquisition. The Cities of Milwaukee and Wauwatosa could, therefore, implement the structure removal portion of the Menomonee River watershed plan utilizing such available federal funds. Communities under 50,000 population, however, must compete for a very limited amount of federal discretionary community development block grants, and the current priority formula for the disposition of such limited funds does not favor the acquisition and removal of floodprone structures. Such communities are left, therefore, with no practical source of state and federal funding in support of implementing the scattered site structure removal portion of the floodland management element of the plan.

Accordingly, it is recommended that the Wisconsin Department of Natural Resources take the lead in assuring that state and federal financial assistance is made available to all communities in the watershed for the purpose of ad hoc, scattered site removal of flood-prone structures in accordance with a duly adopted comprehensive watershed plan. It is suggested that the Department consider revising the rules under which state ORAP grants are currently awarded to enable local communities to obtain financial assistance up to 50 percent of the cost of acquiring scattered site flood-prone structures and of removing such structures. Such rules should not require that the communities involved commit the lands so acquired for public park and open space use, but rather should permit the communities to either retain ownership of the land for possible future public use or to dispose of the lands through sale to abutting landowners, with the proceeds from such sales to be returned to the grantor agency to reduce the net cost of the grant. In addition, it is suggested that the Department request the U. S. Department of the Interior, Bureau of Outdoor Recreation, to similarly amend the LAWCON grant program rules to make scattered site acquisition eligible for federal aid. It is further recommended that the U. S. Department of Housing and Urban Development consider amending its priority formula with respect to discretionary community development block grant funds to give high priority to projects which involve the acquisition and removal of flood-prone homes where floodproofing is inappropriate. In this way the Department, in effect, would be restoring a source of federal funding—the former federal open space land program—to local communities, which source had previously been used successfully for the acquisition and clearance of flood-prone properties.

Bridge Replacement Subelement

It is recommended that any public or private body constructing or financing new bridges or replacing existing bridges over the major stream channel system of the Menomonee River watershed design and construct such bridges in accordance with the water control facility objectives and standards set forth in Chapter II of this volume and with the accompanying design methodology and criteria. The cost of bridge replacement and construction is not included in the recommended watershed plan, since it is assumed that any structures requiring replacement will have served their useful life and will, in any case, require replacement for traffic safety and transportation system construction, operation, and maintenance purposes.

Flood Insurance Subelement

It is recommended that all cities and villages in the watershed continue to participate in the Federal Flood Insurance Program. It is further recommended that the U. S. Department of Housing and Urban Development, in cooperation with the Wisconsin Department of Natural Resources, authorize the conduct of insurance rate studies in the Cities of West Allis and Mequon and the Villages of Germantown and Elm Grove. It is also recommended that the contractors retained by the U. S. Department of Housing and Urban Development to conduct the flood insurance rate studies base those studies on the flood hazard data developed under this study. Finally, it is recommended that owners of property in flood-prone areas purchase flood insurance for protection against losses sustained in future floods.

Lending Institution and Realtor Policies Subelement

It is recommended that lending institutions continue to determine the flood-prone status of properties prior to granting of a mortgage and that the principal source of flood hazard information be that developed under the watershed planning program. It is also recommended that real estate brokers, salesmen, and their agents continue to inform potential purchasers of property of any flood hazard which may exist at the site in accordance with the 1973 executive order by the Governor of Wisconsin.

Community Utility Policies and Emergency Programs Subelement

It is recommended that the policies of governmental units and agencies having responsibility for public utilities and facilities be designed to complement the floodland management regulations for the Menomonee River watershed and the recommended primary environmental corridor subelement. It is further recommended that each watershed community develop procedures to provide floodland residents and other property owners with information about floods already in progress.

Streamflow Recordation Subelement

It is recommended that the U. S. Geological Survey continue to operate the two continuous recorder gages temporarily installed at the N. 70th Street crossing of the Menomonee River in Wauwatosa and on the Menomonee River at Pilgrim Road (CTH YY) in the Village of Menomonee Falls for purposes of the IJC Menomonee River Pilot Watershed Study subsequent to completion of that research project. Upon the completion of the IJC Study, it is recommended that the Wisconsin Department of Natural Resources, in accordance with funding arrangements in effect prior to the IJC Study, finance 50 percent of the cost of operation and maintenance of the continuous recording stream gaging station at N. 70th Street, and that Waukesha County finance 50 percent of the cost of operation and maintenance of the continuous recording stream gaging station at Pilgrim Road. It is further recommended that two of the three partial record stations operated in the watershed by the U. S. Geological Survey in cooperation with the Wisconsin Departments of Transportation and Natural Resources—the Freistadt gage on the Little Menomonee River and the Milwaukee gage on Honey Creek—continue to be operated, and the third gage—the Menomonee Falls gage at the Washington-Waukesha County line—be abandoned since it would be replaced by the recommended continuous stage recorder at Pilgrim Road. It is further recommended that the Village of Menomonee Falls, the City of Milwaukee, and the Milwaukee-Metropolitan Sewerage Commissions continue to maintain their crest stage or staff gage networks and that the Cities of Mequon and Brookfield and the Villages of Germantown and Elm Grove establish and maintain a network of crest stage or staff gages to provide for the acquisition of high water data during flood events. flood events.

It is also recommended that research institutions having responsibilities in water resource and water resource-related areas in the watershed give consideration to the development of research projects, educational programs, and other special studies that could incorporate portions of existing and extensive water quality-quantity monitoring networks within the watershed.

Miscellaneous Measures for the Industrial Valley Subelement

It is recommended that the Milwaukee-Metropolitan Sewerage Commissions set a new flood protection elevation of at least two feet above the 100-year recurrence interval peak flood stage profile for year 2000 land use plan conditions along the Menomonee River in the industrial valley upstream of River Mile 1.75—about N. 25th Street extended. It is further recommended that dikes and floodwalls be raised where necessary to provide protection from flooding under probable future flow conditions.

Maintenance of Stream Channels and Hydraulic Structure Waterway Openings

It is recommended that civil divisions and governmental agencies within the watershed affected by or having jurisdiction over the watershed stream system carry out periodic cleaning and maintenance of both the stream channels and of the bridge and culvert waterway openings.

WATER QUALITY MANAGEMENT PLAN ELEMENT

The water quality management plan element of the recommended comprehensive Menomonee River watershed plan includes completion of the long-range relief sewer construction program currently being conducted by the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee and the abandonment of four existing municipal sewage treatment plants and connection of their service areas to the Milwaukee-Metropolitan sewerage system; implementation of the results of a preliminary engineering study providing recommendations for the elimination of all combined sewer overflows emanating in the 10.7-square-mile combined sewer service area of the Menomonee River watershed; and the elimination of all flow relief device and industrial discharges. The plan also recommends the institution of creosote pollution abatement operations along a reach of the Little Menomonee River; the gradual elimination of onsite sewage disposal systems, and the institution of sound land management practices to control pollution from washoff from the land surface. Finally, the plan recommends the conduct of a continuing water quality monitoring program in the watershed. The water quality management plan element, for purposes of discussion, is divided into the following subelements: municipal sewage treatment plant abandonment, combined sewer overflow elimination, flow relief device elimination, industrial discharge elimination, creosote pollution abatement, onsite sewage disposal system elimination, land management, and continuing water quality monitoring. The recommended water quality management plan element implementation actions are set forth in Table 48, and a schedule of capital and operation and maintenance costs for this plan element are set forth in Table 55.

Municipal Sewage Treatment
Plan Abandonment Subelement

It is recommended that the four existing municipal sewage treatment plants in the watershed be abandoned as set forth in SEWRPC Planning Report No. 16, A Regional Sanitary Sewerage System Plan for Southeastern Wisconsin, 1974. It is further recommended that the Milwaukee-Metropolitan Sewerage Commissions continue their long-range metropolitan district trunk, relief, and interceptor sewer construction program to allow for the timely abandonment of the four municipal sewage treatment plants. Based upon present implementation schedules, it is anticipated that the abandonment of the four existing public sewage treatment plants will occur by 1981.

Combined Sewer Overflow Elimination Subelement

It is recommended that pollution resulting from 25 combined sewer overflows discharging to the Menomonee River downstream of Hawley Road be abated. A preliminary engineering study, called for in the adopted regional sanitary sewer system plan, is underway to provide recommendations for the abatement of the combined sewer overflow problem in the City of Milwaukee. It is proposed that the recommendations of that preliminary engineering study be implemented by the Milwaukee-Metropolitan Sewerage Commissions so as to result in the construction of the necessary facilities needed to abate the combined sewer overflow problem in the Menomonee River watershed as well as in the neighboring Milwaukee and Kinnickinnic River watersheds.

Flow Relief Device Elimination Subelement

It is recommended that the 102 sanitary sewer flow relief devices—crossovers, bypasses, relief pumping stations—discharging to the major streams throughout the Menomonee River watershed be controlled as called for in the adopted regional sanitary sewer system plan. The watershed plan assumes the gradual control of flow relief devices by local and areawide governmental units and agencies through the Wisconsin Pollutant Discharge Elimination System (WPDES) administered by the Wisconsin Department of Natural Resources.

Industrial Discharge Elimination Subelement

It is recommended that the 44 industrial point sources discharging directly or indirectly to the Menomonee River watershed stream system be controlled. The watershed plan assumes the gradual control of these discharges by the industries involved under the Wisconsin Pollutant Discharge Elimination System.

Creosote Pollution Abatement Subelement[12]

It is recommended that Milwaukee County through its Park Commission assume responsibility for the construction of 3.46 miles of new channel adjacent and parallel to the existing channel of the Little Menomonee River between River Mile 5.04 and W. Appleton Avenue at River Mile 1.58, and in addition fill in the existing channel and landscape the disturbed areas. Inasmuch as the bottom muds of the Little Menomonee River containing the creosote would be covered by up to four feet of clean fill material, the associated hazards would be eliminated. A schedule of capital costs associated with this subelement is set forth in Table 55.

Onsite Sewage Disposal System Elimination Subelement

It is recommended that onsite sewage disposal systems, used by approximately 14 percent of the Menomonee River watershed population, be eliminated as proposed in the regional sanitary sewerage system plan, by the provision of sanitary sewer service to presently unsewered urban areas. Furthermore, it is recommended that all planned urban development in the watershed be served by sanitary sewers. Provision of the recommended sanitary sewer service will require continuing cooperative efforts by the local units of government and the Milwaukee-Metropolitan Sewerage Commissions.

Land Management Subelement

It is recommended that pollution in rural areas caused by runoff of agricultural land be controlled primarily through the application of basic land conservation measures such as contour plowing, strip cropping, and minimum tillage supplemented by the judicious application of other measures including bench terraces. Technical and financial assistance in the design and implementation of a land management program for a given farmstead is available from the U. S. Department of Agriculture, Soil Conservation Service and Agricultural Stabilization and Conservation Service and from the local soil and water conservation districts.

It is recommended that pollution caused by washoff from barnyards and feedlots be abated by the construction of feedlot runoff pollution control systems at approximately 40 barnyards and feedlots in the watershed. These systems would consist primarily of drainage control around each feedlot and provision of manure storage facilities. Technical assistance in selecting and designing feedlot pollution control measures is available through the U. S. Department of Agriculture, Soil Conservation Service, and financial assistance for implementation may be available through the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service.

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[12] *As a result of the creosote pollution problem, Milwaukee County has filed suit against Moss-American, Inc., for $500,000 in damages. That suit was pending in federal court as of June 1976.*

With respect to diffuse source pollution control in urban areas, it is recommended that the communities in the watershed use a judicious blend of education and ordinance to encourage citizens to apply low or no-cost measures such as the following: control of littering by domestic animals, proper application of chemical and organic fertilizers and pesticides to lawns, control of litter and debris in proper material storage in private property and in public places, and control of sediment and debris during demolition and construction activities. It is also recommended that communities examine the manner in which municipal services such as street cleaning and maintenance, street de-icing, and garbage collection are performed to determine if the average amount of dust and dirt that accummulates on road surfaces, and therefore is subject to washoff in the stream system, can be significantly reduced with little or no increase in cost. It is also recommended that community officials encourage land developers to consider the use of detention-retention storage as a means of reducing the washoff of potential pollutants from the land surface to the surface waters—in addition to possibly reducing the cost of storm water control and achieving recreational and aesthetic benefits.

Continuing Water Quality Monitoring Subelement

It is proposed that recommendations be developed in other areawide water quality planning and management programs concerning a continuing surface water quality monitoring programs in the Region, to be published in early 1977, and to be considered by the Menomonee River Watershed Committee for incorporation into the water quality management plan element of the Menomonee River watershed plan inasmuch as these recommendations apply to the Menomonee River watershed.

RELATIONSHIP OF THE WATERSHED PLAN TO ENVIRONMENTAL IMPACT STATEMENTS

Section 102(c) of the National Environmental Policy Act of 1969 requires the preparation by appropriate officials of detailed statements which assess the impact on the environment of nearly all development proposals and projects which in any way involve federal participation. Such statements must be addressed to an assessment of the environmental impact of the proposed project, to any unavoidable adverse environmental effects, to alternatives to the proposed project, to the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and to any irreversible and irretrievable commitments of natural resources caused by the projected project. Such environmental impact statements are intended to provide an additional basis for the review of proposed capital improvement projects and are important in assuring that the decision-making process for federally aided public works of improvement includes adequate consideration of the potential effect of the project on the environment.

The inventory data, extensive analyses, alternative plan elements, and recommended comprehensive plan for the Menomonee River watershed presented in summary form in the two volumes of this planning report constitute, in effect, a comprehensive environmental impact statement. In particular, positive and negative features of the various alternative subelements considered in synthesis of the comprehensive plan are discussed in Volume 2 in Chapter III, " Land Use Base and Alternative Natural Resource Protection Measures," Chapter IV, "Alternative Floodland Management Measures," and Chapter V, "Alternative Water Quality Management Measures." Furthermore, Chapter VI, Volume 2, "Recommended Comprehensive Plan," contains an evaluation of the ability of the plan to meet the adopted objectives and standards and also describes the likely negative consequences of not implementing the recommended plan.

As a comprehensive design for the preservation and protection of the natural resource base and for the maintenance and enhancement of the overall quality of the environment within the Menomonee River watershed, the plan should provide the basis for preparation of future environmental impact statements with respect to specific proposals for land and water resource-related public works construction within the watershed. Moreover, each such future environmental impact statement should be carefully related to the recommended comprehensive watershed plan and should demonstrate how the particular project under consideration would assist in achieving the objectives, principles, and standards which underlie and have formed the basis for the recommended comprehensive watershed plan.

FINANCIAL AND TECHNICAL ASSISTANCE

Upon adoption of the various land use, floodland management, and water quality management plan elements and any necessary schedules of capital costs and operation and maintenance expenditures, it becomes necessary for the areawide governmental agencies concerned and the local units of government within the watershed to utilize effectively all sources of financial and technical assistance available for the timely execution of the recommended plan elements. In addition to current tax revenue sources, such as property taxes, fees, fines, public utility earnings, highway aids, educational aids, and state-collected taxes, the areawide agencies and local units of government also can make use of other revenue sources, such as borrowing, special taxes and assessments, state and federal grants, and gifts. Various types of technical assistance useful in plan implementation are also available from county, state, and federal agencies. The type of assistance extends from the technical advice on land and water management practices provided by the U. S. Soil Conservation Service to the educational, advisory, and review services offered by the University of Wisconsin-Extension and the Regional Planning Commission itself.

Borrowing

Areawide agencies and local units of government are normally authorized to borrow so as to effectuate their powers and discharge their duties. Chapter 67 of the Wisconsin Statutes generally empowers counties, cities, villages, and towns to borrow money and to issue municipal obligations not to exceed 5 percent of the equalized assessed valuation of its taxable property, with certain

Table 55

SCHEDULE OF CAPITAL AND OPERATION AND MAINTENANCE COSTS OF THE WATER QUALITY MANAGEMENT PLAN ELEMENT OF THE RECOMMENDED COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED BY COUNTY AND YEAR: 1977-2000

County	Calendar Year	Project Year	Abate Creosote Pollution: Construction (in Dollars)	Control Runoff from Animal Feedlots[a]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Agricultural Lands[b]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Urban Lands[c]: Operation and Maintenance (in Dollars)	Total (in Dollars)
Milwaukee	1977	1	40,200	--	5,100	262,500	307,800
	1978	2	40,200	--	5,100	262,500	307,800
	1979	3	40,200	--	5,100	262,500	307,800
	1980	4	40,200	--	5,100	262,500	307,800
	1981	5	40,200	--	5,100	262,500	307,800
	1982	6	--	--	--	262,500	262,500
	1983	7	--	--	--	262,500	262,500
	1984	8	--	--	--	262,500	262,500
	1985	9	--	--	--	262,500	262,500
	1986	10	--	--	--	262,500	262,500
	1987	11	--	--	--	262,500	262,500
	1988	12	--	--	--	262,500	262,500
	1989	13	--	--	--	262,500	262,500
	1990	14	--	--	--	262,500	262,500
	1991	15	--	--	--	262,500	262,500
	1992	16	--	--	--	262,500	262,500
	1993	17	--	--	--	262,500	262,500
	1994	18	--	--	--	262,500	262,500
	1995	19	--	--	--	262,500	262,500
	1996	20	--	--	--	262,500	262,500
	1997	21	--	--	--	262,500	262,500
	1998	22	--	--	--	262,500	262,500
	1999	23	--	--	--	262,500	262,500
	2000	24	--	--	--	262,500	262,500
County Total			201,000	--	25,500	6,301,000	6,527,500
County Annual Average			8,400	--	1,050	262,500	272,000

County	Calendar Year	Project Year	Abate Creosote Pollution: Construction (in Dollars)	Control Runoff from Animal Feedlots[a]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Agricultural Lands[b]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Urban Lands[c]: Operation and Maintenance (in Dollars)	Total (in Dollars)
Ozaukee	1977	1	--	36,000	7,900	6,500	50,400
	1978	2	--	36,000	7,900	6,500	50,400
	1979	3	--	36,000	7,900	6,500	50,400
	1980	4	--	36,000	7,900	6,500	50,400
	1981	5	--	36,000	7,900	6,500	50,400
	1982	6	--	--	--	6,500	6,500
	1983	7	--	--	--	6,500	6,500
	1984	8	--	--	--	6,500	6,500
	1985	9	--	--	--	6,500	6,500
	1986	10	--	--	--	6,500	6,500
	1987	11	--	--	--	6,500	6,500
	1988	12	--	--	--	6,500	6,500
	1989	13	--	--	--	6,500	6,500
	1990	14	--	--	--	6,500	6,500
	1991	15	--	--	--	6,500	6,500
	1992	16	--	--	--	6,500	6,500
	1993	17	--	--	--	6,500	6,500
	1994	18	--	--	--	6,500	6,500
	1995	19	--	--	--	6,500	6,500
	1996	20	--	--	--	6,500	6,500
	1997	21	--	--	--	6,500	6,500
	1998	22	--	--	--	6,500	6,500
	1999	23	--	--	--	6,500	6,500
	2000	24	--	--	--	6,500	6,500
County Total			--	180,000	39,600	155,000	374,600
County Annual Average			--	7,500	1,650	6,500	15,600

Table 55 (continued)

County	Calendar Year	Project Year	Abate Creosote Pollution: Construction (in Dollars)	Control Runoff from Animal Feedlots[a]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Agricultural Lands[b]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Urban Lands[c]: Operation and Maintenance (in Dollars)	Total (in Dollars)
Washington	1977	1	--	44,000	22,200	25,800	92,000
	1978	2	--	44,000	22,200	25,800	92,000
	1979	3	--	44,000	22,200	25,800	92,000
	1980	4	--	44,000	22,200	25,800	92,000
	1981	5	--	44,000	22,200	25,800	92,000
	1982	6	--	--	--	25,800	25,800
	1983	7	--	--	--	25,800	25,800
	1984	8	--	--	--	25,800	25,800
	1985	9	--	--	--	25,800	25,800
	1986	10	--	--	--	25,800	25,800
	1987	11	--	--	--	25,800	25,800
	1988	12	--	--	--	25,800	25,800
	1989	13	--	--	--	25,800	25,800
	1990	14	--	--	--	25,800	25,800
	1991	15	--	--	--	25,800	25,800
	1992	16	--	--	--	25,800	25,800
	1993	17	--	--	--	25,800	25,800
	1994	18	--	--	--	25,800	25,800
	1995	19	--	--	--	25,800	25,800
	1996	20	--	--	--	25,800	25,800
	1997	21	--	--	--	25,800	25,800
	1998	22	--	--	--	25,800	25,800
	1999	23	--	--	--	25,800	25,800
	2000	24	--	--	--	25,800	25,800
County Total			--	220,000	110,800	618,000	948,800
County Annual Average			--	9,150	4,600	25,800	39,500

County	Calendar Year	Project Year	Abate Creosote Pollution: Construction (in Dollars)	Control Runoff from Animal Feedlots[a]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Agricultural Lands[b]: Construction (in Dollars)	Reduce Diffuse Source Pollution from Urban Lands[c]: Operation and Maintenance (in Dollars)	Total (in Dollars)
Waukesha	1977	1	--	--	10,900	134,300	145,200
	1978	2	--	--	10,900	134,300	145,200
	1979	3	--	--	10,900	134,300	145,200
	1980	4	--	--	10,900	134,300	145,200
	1981	5	--	--	10,900	134,300	145,200
	1982	6	--	--	--	134,300	134,300
	1983	7	--	--	--	134,300	134,300
	1984	8	--	--	--	134,300	134,300
	1985	9	--	--	--	134,300	134,300
	1986	10	--	--	--	134,300	134,300
	1987	11	--	--	--	134,300	134,300
	1988	12	--	--	--	134,300	134,300
	1989	13	--	--	--	134,300	134,300
	1990	14	--	--	--	134,300	134,300
	1991	15	--	--	--	134,300	134,300
	1992	16	--	--	--	134,300	134,300
	1993	17	--	--	--	134,300	134,300
	1994	18	--	--	--	134,300	134,300
	1995	19	--	--	--	134,300	134,300
	1996	20	--	--	--	134,300	134,300
	1997	21	--	--	--	134,300	134,300
	1998	22	--	--	--	134,300	134,300
	1999	23	--	--	--	134,300	134,300
	2000	24	--	--	--	134,300	134,300
County Total			--	--	54,500	3,222,000	3,276,500
County Annual Average			--	--	2,250	134,300	136,500
Watershed Total			201,000	400,000	230,400	10,296,000	11,127,400
Watershed Annual Average			8,400	16,700	9,600	429,000	463,700

[a] *Assumes the installation of feedlot pollution control measures to 40 barnyards or feedlots in the watershed—about 80 percent of the total—at a capital cost of $10,000 per acre.*

[b] *Assumes the application of contour plowing, strip cropping, or minimum tillage or various combinations of these measures, at a capital cost of $10 per acre, to the 36 square miles of cropland and pasture in the watershed having a slope of 2 percent or more.*

[c] *Assumes application of improved street cleaning procedures to 67 square miles of urban land at an incremental annual cost of $10 per acre per year.*

Source: SEWRPC.

exceptions, including school bonds and revenue bonds. Such borrowing powers, which are related directly to implementation of the comprehensive Menomonee River watershed plan, include these:

1. Counties may issue bonds for county park and related open space land acquisition and development.

2. Cities and villages may borrow and issue bonds for the construction of water supply and distribution systems, for sewage treatment plants, and for park and related open space land acquisition and development.

3. Towns may issue bonds for acquiring river fronts, lakeshore, woodlots, and scenic and historic sites.

Section 60.307 of the Wisconsin Statutes specifically authorizes town sanitary districts to borrow money and to issue bonds for the construction or extension of storm sewer, sanitary sewer, and water supply systems. Sections 66.202 and 59.96(7) of the Wisconsin Statutes authorize metropolitan sewerage districts to borrow money and to issue bonds for the construction of sanitary sewerage facilities. Farm drainage boards are authorized under Section 88.12 of the Wisconsin Statutes to issue bonds for any and all of their functions. In addition, the powers of cooperative contract commissions created under Section 66.30 of the Wisconsin Statutes were recently clarified[13] to include borrowing by the contracting bodies of such commissions for acquiring, constructing, and equipping areawide projects.

Federal advances and loan programs have been largely supplanted by federal block grant programs. These programs are discussed under the section entitled "Park and Open Space Land and Development Grants."

Special Taxes and Assessments

Counties and cities have special assessment powers for park and parkway acquisition and improvements under Sections 27.065 and 27.10(4), respectively, of the Wisconsin Statutes. Counties are empowered under Section 27.06 of the Wisconsin Statutes to levy a mill tax to be collected into a separate fund and to be paid out only upon order of the county park commission for the purchase of land and other commission expenses. Farm drainage boards, town sanitary districts, metropolitan sewerage districts, cities, and villages also have taxing and special assessment powers under Sections 88.06, 63.06, 60.39, 59.96(9), and 62.18(16) of the Wisconsin Statutes. Although soil and water conservation districts have no taxing, bonding, or assessment powers, such districts may recover the cost and expenses, with interest, of performing work or operations, as authorized by a court under Section 92.11 of the Wisconsin Statutes.

Park and Open Space Land and Development Grants

Several federal grant programs are available to state and local units of government, and one state grant program is available to local units of government for the financing of park land acquisition and development. In general, the local units of government and agencies in the Region are eligible for these grants; however, the eligibility of individual projects is based upon certain planning and other prerequisites and must be determined for each specific project. The following is a brief description of these programs.

State Local Park Aids Program (ORAP): This program, administered by the Wisconsin Department of Natural Resources, provides grants to all local units of government in amounts up to 50 percent of the cost of acquiring and developing recreational lands and rights-in-land to be used for local park and open space systems. Such state funds can also be used to help match federal funds.

Community Development Block Grants Program: This program, authorized under Title I of the Housing and Community Development Act of 1974, Public Law 93-383, and administered by the U. S. Department of Housing and Urban Development, consolidates seven former community development-type categorical programs and provides grants to cities for the acquisition and development of land for park and open spaces, in addition to urban beautification, and sewer and water facilities grants. These grants are available as entitlement grants to cities with populations in excess of 50,000 and are available as discretionary grants to communities of under 50,000 persons.

Federal Land and Water Conservation Fund: This program, administered by the U. S. Department of the Interior, Bureau of Outdoor Recreation, through the Wisconsin Department of Natural Resources, provides grants to state and local units of government in amounts up to 50 percent of the cost of acquisition and improvement of outdoor recreation areas.

Water Supply and Sewerage System Grants

One state and one federal grant program are available to local units of government for the financing of water systems, sewer facilities, storm water drainage systems, and sewage treatment facilities. A brief description of these two programs follows.

State Water Pollution Prevention and Abatement Programs: This program, administered by the Wisconsin Department of Natural Resources pursuant to the rules set forth in Chapter NR 125 of the Wisconsin Administrative Code, provides financial assistance to local governments for the cost of approved pollution abatement and prevention projects. Eligible projects include waste treatment facilities; trunk, relief, and intercepting sewers; outfall sewers; certain sewage collection systems; and other appurtenances. It is anticipated that all facility recommendations included in the water quality management element of the watershed plan would be eligible for state financial assistance. For nonfederally aided projects, the state grant is 25 percent of the total cost. For projects receiving federal aid, the state grant offer may amount to 5 percent to provide combined state and federal assistance in the amount of 80 percent of the cost of the

[13] *Chapter 238, Laws of Wisconsin, 1965.*

project, except that combined state and federal assistance may extend to 90 percent of the cost of that part of the project consisting of advanced or tertiary sewage treatment components.

Federal Waste Treatment Works Construction Program: This program, administered by the U. S. Environmental Protection Agency, provides federal financial assistance in an amount of 75 percent of the total cost of approved project. Projects must be found to be in conformance with an approved facility plan and areawide water quality management or Section 303 basin plan, as applicable. It is anticipated that all facilities included in the recommended regional sanitary sewerage system plan will be eligible for 75 percent federal assistance under this program.

Soil and Water Conservation Grants

There are several programs available for conservation and protection of the agricultural lands and environmental corridors recommended in the Menomonee River watershed plan for preservation. A brief description of these programs follows.

State Soil and Water Conservation Program: This program, administered by the Wisconsin Board of Soil and Water Conservation Districts, provides grants to the county soil and water conservation districts in amounts up to 50 percent toward the cost of approved soil and water conservation projects.

Federal Agricultural Conservation Program: This program, administered by the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, provides grants to farmers for carrying out approved soil, water, woodland, and wildlife conservation practices.

Federal Resource Conservation and Development Program: This program, administered by the U. S. Department of Agriculture, Soil Conservation Service, provides cost sharing up to 100 percent for flood control and sediment control works and up to 50 percent for construction of water conservation works, structural recreation works, and improved land use measures.

Federal Cropland Adjustment Program: This program, also administered by the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service, provides grants in amounts up to 50 percent of the cost to farmers to divert cropland to protective conservation uses for 5- to 10-year periods, the cost being based upon the value of the crops which would be produced. This program also provides cost sharing up to 50 percent toward the cost of carrying out good conservation practices, such as establishment of vegetative cover, forest cover, good wildlife habitat, and preservation of natural beauty.

Federal Multiple-Purpose Watershed Program: This program, administered by the U. S. Department of Agriculture, Soil Conservation Service, through the State Soil Conservation Board, provides cost sharing up to 100 percent to qualified sponsors, such as soil and water conservation, flood control, drainage, or irrigation districts for flood prevention works and up to 50 percent towards agricultural water management, public recreation, fish and wildlife development, acquisition of certain recreational land rights, and agricultural land planning and treatment.

State Water Quality Regulation Enforcement Program: This program, administered by the Wisconsin Department of Natural Resources, provides annual grants to counties in amounts up to $1,000 in partial support of the cost of administering and enforcing county water protection or shoreland use regulations.

Federal Water Resources Investigation Program

The U. S. Department of the Interior, Geological Survey, administers a cooperative water resources investigation program that provides federal matching funds in amounts up to 50 percent of the cost of projects under the program. This program includes the installation, calibration, operation, and maintenance of stream gage recording stations.

General Works Projects—U. S. Army Corps of Engineers

Substantial federal financial and technical assistance is available for the construction of approved flood control works under the general works projects program carried out by the U. S. Army Corps of Engineers upon U. S. Congressional approval of a particular project. After feasibility studies and public hearings, the U. S. Army Corps of Engineers will undertake the construction of such flood control works as levees, dams, and reservoirs. All lands, easements, and necessary rights-of-way and other costs in accordance with established cost sharing policies, however, must be provided by the local unit of government. In addition, the local unit of government must agree to maintain and to operate all facilities constructed under the program in accordance with regulations prescribed by the Secretary of the Army.

Gifts

Donations of lands, interests in lands, or monies from private individuals and corporations should not be overlooked as sources of possible assistance in regional plan implementation, particularly with respect to park acquisition and environmental corridor preservation. The potential contributions, both in leadership and funds, from private groups should not be underestimated. Such gifts, either in lands, interests in lands, or monies, may, moreover, be used toward the local contribution in obtaining various state and federal grants.

Technical Assistance

Certain federal, state, regional, and county agencies provide various levels and types of technical assistance useful in watershed plan implementation to local units of government upon request. Limited guidance and assistance are usually provided without cost, or such assistance may be provided for a nominal fee. In some cases the local unit of government may contract with the agency for more extensive technical assistance services. A summary of the various levels and types of assistance available by agency follows.

Federal Agencies: The U. S. Department of Agriculture, Soil Conservation Service, provides technical assistance to local units of government and soil and water conservation districts for resource conservation, development, and utilization programs. The Soil Conservation Service also provides technical assistance to local units of government in the adaptation of the detailed operational soil survey and interpretive analyses to urban planning and development problems under a "Memorandum of Understanding" with the Commission.

The U. S. Department of the Interior, Bureau of Outdoor Recreation, provides limited technical assistance and advice to local units of government and private interests in recreational resource planning and programming.

The U. S. Environmental Protection Agency provides technical assistance and advice on request at no cost to state and local units of government and private firms relative to water quality problems.

State Agencies: The University of Wisconsin Extension, through the county agents and extension specialists, provides important educational and technical assistance to farmers and to local units of government in public affairs, soil and water conservation, and outdoor recreation. An example of such university assistance having a direct relationship to watershed plan implementation is the educational services on the use and adaptation of the detailed operational soil survey and interpretive analyses being provided under the previously cited "Memorandum of Understanding" between the University and the Commission. Since the work of the Commission is entirely advisory, the importance of organized educational efforts directed at achieving public understanding and acceptance of the regional plans cannot be overestimated. The University Extension can, in this respect, fulfill an indirect, yet most important, plan implementation function.

The Wisconsin Department of Natural Resources provides advice on water problems; fish management; and forest planting, protection, management, and harvesting and will contract with counties to prepare outdoor recreation plans which would establish county eligibility under the Federal Land and Water Conservation Program.

The Wisconsin Department of Natural Resources provides plan review services and supervision of the operation of public water supply and sewage treatment facilities and is authorized to provide technical assistance to local units of government and private groups in their efforts to initiate or engage in specific types of development, such as parks, recreation, resource development, water supply, and sewage disposal. The Department was recently authorized to extend assistance to local units of government for the purpose of securing uniformity of water resource protection regulations.

The State Board of Soil and Water Conservation Districts is authorized to provide assistance to landowners and the county soil and water conservation districts in carrying out soil and water conservation practices.

Areawide Agencies: The Southeastern Wisconsin Regional Planning Commission, through its Community Assistance Division, provides limited educational, advisory, and review services to the local units of government, including participation in educational programs, such as workshops; provision of speakers; sponsorship of regional planning conferences; publication of bimonthly newsletters; selection of staff and consultants; preparation of planning programs; special base and soil mapping, preparation of suggested zoning, official mapping, and land division ordinances; information regarding federal and state aid programs; and the review of local planning programs, plan proposals, ordinances, and most state and federal grant applications. In addition, the Commission is empowered to contract with local units of government under Section 66.30 of the Wisconsin Statutes to make studies and offer advice on land use, transportation, community facilities, and other public improvements.

County Agencies: The County Soil and Water Conservation Districts are authorized to cooperate in furnishing technical assistance to landowners or occupiers and any public or private agency in preventing soil erosion and floodwater and sedimentation damage and in furthering water conservation and development.

Those counties with park or planning staffs provide certain technical services related to park design and general community planning and development problems to local units of government and private groups.

SUMMARY

This chapter has described the various means available and has recommended specific procedures for implementation of the recommended comprehensive Menomonee River watershed plan. The most important recommended plan implementation actions are summarized in the following paragraphs by level of government, responsible agency or unit of government, and plan elements.

Federal Level

U. S. Department of Housing and Urban Development: It is recommended that the U. S. Department of Housing and Urban Development:

1. Endorse the comprehensive Menomonee River watershed plan and use such plan as a guide in the administration and granting of federal aids for community development and in the administration of the national flood insurance program.

2. Assign the highest appropriate priorities to all applications for community development block grants that are in support of the acquisition and development of those park and open space sites recommended for public use in the plan.

3. Approve only those applications for sewer and water facility block grants that are located and designed in accordance with the land use and water quality management elements of the Menomonee River watershed plan.

4. Amend the priority formula for all community development block grant funds to give high priority to projects which involve the acquisition and removal of flood-prone homes where floodproofing is inappropriate.

U. S. Environmental Protection Agency: It is recommended that the U. S. Environmental Protection Agency:

1. Accept the recommended Menomonee River watershed plan upon state certification thereof and utilize the plan as a guide in the administration and granting of federal aids for the construction of sewage treatment plants and related facilities within the watershed.

U. S. Department of the Interior, Bureau of Outdoor Recreation: It is recommended that the U. S. Department of the Interior, Bureau of Outdoor Recreation:

1. Acknowledge the Menomonee River watershed plan and utilize the plan in its administration and granting of aids under the Land and Water Conservation Fund Act.

2. In cooperation with the Wisconsin Department of Natural Resources, amend the federal LAWCON grant-in-aid rules so that such monies can be utilized by local communities for the purpose of ad hoc, scattered site acquisition and removal of flood-prone structures where floodproofing is inappropriate.

U. S. Department of the Interior, Geological Survey: It is recommended that the U. S. Department of the Interior, Geological Survey:

1. Endorse the comprehensive Menomonee River watershed plan and continue to maintain a cooperative program of water resources investigation in the watershed, including the continued operation of two continuous stream gaging stations in the basin.

U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service: It is recommended that the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service:

1. Acknowledge the recommended Menomonee River watershed plan and utilize the plan in the administration of its agricultural conservation programs.

U. S. Department of Agriculture, Soil Conservation Service: It is recommended that the U. S. Department of Agriculture, Soil Conservation Service:

1. Acknowledge the recommended Menomonee River watershed plan and utilize the plan as a guide in the administration and granting of federal aids for resource conservation and development and for construction of multipurpose watershed projects within the Region and in the provision of technical assistance for land and water conservation.

U. S. Department of the Army, Corps of Engineers: It is recommended that the U. S. Department of the Army, Corps of Engineers:

1. Acknowlege the recommended Menomonee River watershed plan and cooperate with any local or state units and agencies of government in any requests for assistance in implementation of the floodland management element of the Menomonee River watershed plan.

State Level

Wisconsin Department of Natural Resources: It is recommended that the State Natural Resources Board and the Department of Natural Resources:

1. Endorse the comprehensive Menomonee River watershed plan and direct its integration into the various conservation, park and outdoor recreation, environmental protection, water control, and technical and financial assistance programs conducted by various divisions of the Department.

2. Certify the Menomonee River watershed plan to the U. S. Environmental Protection Agency as a river basin plan for state and federal planning purposes.

3. Conduct periodic water pollution control surveys of the Menomonee River Basin and reevaluate, amending as necessary, and enforce outstanding pollution control orders in accordance with pollution abatement recommendations, as set forth in the Menomonee River watershed plan.

4. Endorse the recommended water quality management plan element for the Menomonee River watershed which seeks to abate pollution in the Menomonee River stream system and reflect such endorsement through the continual review and amendment of permits issued under Wisconsin Pollutant Discharge Elimination System.

5. Give due weight to the recommended Menomonee River watershed plan in the exercise of the Department's various water regulatory functions, including approval of floodland regulations and the issuance of permits dealing with proposed river crossings and channel-floodplain alterations.

6. Encourage counties and local units of government in the watershed to follow the watershed plan recommendations relative to floodland and shoreland zoning when review is made of floodland and shoreland zoning ordinances prepared by such local units of government, pursuant to Sections 59.971 and 87.30 of the Wisconsin Statutes.

7. Adopt the regional soil survey and analyses as a guide in regulating installation of soil absorption sewage disposal systems within the watershed, prohibiting the installation of such systems on soils within the watershed that have very severe limitations for the absorption of sewage effluent, as determined by the detailed operational soil surveys.

8. Endorse and integrate the primary environmental corridor plan element of the recommended Menomonee River watershed plan into the State long-range conservation and outdoor recreation plans as a guide to park and related open space development and to resource conservation and management practices within the watershed.

9. Assign the highest appropriate priorities to all Federal Land and Water Conservation Fund (LAWCON) or State Local Park Aids Program (ORAP) local park aid applications for land located within the primary environmental corridors.

10. Approve only such applications for state and federal aids in partial support of the construction and improvement of municipal pollution prevention and abatement facilities that are located and designated in general concurrence with the recommended Menomonee River watershed plan.

11. Recommend to the State Legislature that consideration be given to the establishment of a Greenway Tax Law patterned after the well-established Forest Crop Law and directed toward providing property tax incentives for private landowners who retain and manage high-value woodlands throughout the watershed and the state.

12. Increase the amount of technical aid and assistance to private landowners relative to the proper management of woodland and wetland resources.

13. Continue the operation and maintenance of stream flow gages in cooperation with the U. S. Geological Survey.

14. Take the lead in assuring that state ORAP and/or federal LAWCON funds are made available to local communities to obtain financial assistance up to 50 percent of the cost of acquiring and removing scattered site flood-prone structures in accordance with a duly adopted comprehensive watershed plan.

Wisconsin Department of Local Affairs and Development: It is recommended that the Wisconsin Department of Local Affairs and Development:

1. Endorse the comprehensive Menomonee River watershed plan and direct its integration into the various functions of the Department.

2. Give due weight to the recommended Menomonee River watershed land use plan element in reviewing proposed annexations, incorporations, and consolidations.

3. Promote implementation of the Menomonee River watershed plan in its program of providing technical assistance to local units of government.

4. Take the lead in initiating a legislative study designed to probe the inconsistencies now existing between property taxation and land development policies in Wisconsin and recommend appropriate remedial action.

Wisconsin Department of Transportation: It is recommended that the Department of Transportation:

1. Give due weight to the recommended Menomonee River watershed plan in its transportation facility planning and construction activities, with particular respect to the alignment of right-of-ways and replacement of bridge structures in the stream valleys of the watershed so that the flood control objectives of the watershed plan are achieved.

2. Coordinate the establishment, signing and marking, and maintenance of the recommended system of Menomonee River scenic drives and urban interconnecting streets in cooperation with the four county highway committees concerned.

3. Continue the operation and maintenance of streamflow gages in conjunction with the U. S. Geological Survey.

Wisconsin Department of Health and Social Services, Division of Health: It is recommended that the Health and Social Services Board and the State Division of Health:

1. Endorse the comprehensive Menomonee River watershed plan, with particular respect to the land use plan element and the rational urban service areas implied therein in the exercise of its subdivision review and approval powers.

2. Adopt the regional soil survey and analyses as a guide in reviewing subdivision plats so as to prohibit the installation of soil absorption sewage disposal systems on soils that have very severe limitations for such systems, thereby delaying the subdivision of land covered by such soils until such time as public sanitary sewerage service becomes available.

Wisconsin Board of Soil and Water Conservation Districts: It is recommended that the Wisconsin Board of Soil and Water Conservation Districts:

1. Endorse the comprehensive Menomonee River watershed plan, with particular respect to the recommended land use plan element, including

the agricultural land use and environmental corridor recommendations, as a guide in the coordination of County Soil and Water Conservation Districts projects.

2. Apportion appropriate federal and state funds to the County Soil and Water Conservation Districts within the watershed to assist them in implementing agricultural land management subelements of the recommended watershed plan.

Areawide Level

Metropolitan Sewerage District of the County of Milwaukee: It is recommended that the Sewerage Commission of the City of Milwaukee and the Metropolitan Sewerage Commission of the County of Milwaukee, acting as agents for the Metropolitan Sewerage District of the County of Milwaukee:

1. Adopt the recommended Menomonee River watershed plan, including the land use, floodland management, and water quality management elements, and thereafter determine the proposed sewer service areas in accordance with the plan.

2. Complete the long-range trunk and relief sewer construction program in Milwaukee County in order to allow the abandonment of the four existing municipal sewage treatment plants in the watershed, and abate the pressing water pollution problems in the Menomonee River watershed caused by separate sanitary sewer overflows.

3. Construct and maintain 1.65 miles of major channelization in the Cities of Wauwatosa and Milwaukee between N. 70th and N. 45th Streets.

4. Undertake responsibility for implementation of the plan recommendation dealing with the abatement of pollution caused by combined sewer overflows in the Menomonee River watershed (Sewerage Commission of the City of Milwaukee).[14]

5. Continue their program of monitoring stream stages in the Menomonee River watershed.

6. Set a new flood protection elevation along the Menomonee River in the industrial valley and raise dikes and floodwalls as necessary to provide protection from probable future flood flows in that area.

7. Clean and maintain, in cooperation with local units of government, stream channels and hydraulic structure waterway openings.

Jackson-Germantown Drainage District: It is recommended that the Jackson-Germantown Drainage District:

1. Acknowledge the recommended Menomonee River watershed plan, particularly the land use and floodland management plan elements.

[14] *Parentheses indicate that the recommended action is only applicable to the named unit or units of government.*

Underwood Sewer Commission: It is recommended that the Underwood Sewer Commission:

1. Adopt the recommended Menomonee River watershed plan, especially the floodland management and water quality management plan elements.

2. Construct and maintain a detention reservoir on Dousman Ditch in the City of Brookfield and help to implement in the recommended replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad Bridge over Underwood Creek in the City of Brookfield.

3. Clean and maintain, in cooperation with the Village of Elm Grove, the City of Brookfield, and the Wisconsin Department of Natural Resources, stream channels and hydraulic structure waterway openings.

Menomonee South Sewerage Commission: It is recommended that the Menomonee South Sewerage Commission:

1. Adopt the recommended Menomonee River watershed plan, particularly the water quality management plan element.

Local Level

Milwaukee, Ozaukee, Washington, and Waukesha County Boards of Supervisors: It is recommended that the county boards of the four major constituent counties comprising the Menomonee River watershed, upon the recommendation of the appropriate agencies and committees:

1. Adopt the recommended Menomonee River watershed plan, as it applies to each county, as a guide to the future development of the Menomonee River watershed portion of the county.

2. Support the establishment of the Menomonee River Watershed Committee by the Southeastern Wisconsin Regional Planning Commission as a continuing intergovernmental advisory body concerned with watershed plan adjustment and implementation.

3. Adopt the regional land use and transportation plan.

4. Consider the establishment of a county park and planning commission and reassign, as appropriate, all county zoning, subdivision plat review, and park and recreation functions (Ozaukee).

5. Officially adopt the land use plan element of the Menomonee River watershed plan.

6. Adopt the recommended "Schedules of Capital Costs" as a guide to plan implementation and annually consider allocation of monies for implementation, including the purchase of land designated as primary environmental corridor, construction and maintenance of parkway

drives and recreational trails, and the signing and marking of scenic drives and interconnecting urban streets.

7. Continue the operation and maintenance of streamflow gages in cooperation with the U. S. Geological Survey (Waukesha).

8. Adopt soil and conservation land use regulations, as formulated by the soil and water conservation district supervisors.

9. Report to the Wisconsin Department of Natural Resources any alleged encroachments on the navigable channels of the Menomonee River system.

10. Establish, in cooperation with the Wisconsin Department of Transportation and upon recommendation of the respective county highway committee, the establishment of a Menomonee River scenic drive and interconnecting urban street system.

11. Continue to participate in the Federal Flood Insurance program (Washington and Waukesha).

Milwaukee, Ozaukee, Washington, and Waukesha County Park and Planning Agencies: It is recommended that the Milwaukee, Ozaukee, Washington, and Waukesha County park and planning agencies:

1. Recommend to the county board adoption of the land use plan element, with its overall land use, primary environmental corridor, and parkway drive-scenic drive-recreational trail subelements of the recommended Menomonee River watershed plan.

2. Construct a new channel, fill in the existing channel, and landscape disturbed areas along the Little Menomonee River to alleviate the creosote pollution problem (Milwaukee County).

3. Formulate detailed county plans for the ultimate acquisition of the selected primary environmental corridors (Milwaukee, Washington, and Waukesha Counties).

4. Include in the detailed county park plan measures for the ultimate removal on a voluntary basis of selected residences located in the floodplain of the Menomonee River and its major tributaries (Milwaukee and Waukesha Counties).

5. Develop the recommended parkway pleasure drive system and recreational trail system (Milwaukee, Washington, and Waukesha Counties).

Soil and Water Conservation Districts: It is recommended that the Soil and Water Conservation Districts of Milwaukee, Ozaukee, Washington, and Waukesha Counties:

1. Adopt the recommended Menomonee River watershed plan as it affects each respective district and request cooperating federal and state agencies to provide such assistance as would serve to implement the recommended land use, natural resource protection, and water pollution abatement plan elements.

2. Formulate, as appropriate, soil and water conservation regulations necessary to assist in implementation of the recommended watershed land use and natural resource protection plan elements.

Common Councils, Village Boards, and Town Boards: It is recommended that, upon referral to and upon recommendation of the local plan commissions, each common council, village board, and town board within the watershed, as appropriate and as noted:

1. Support the establishment of the Menomonee River Watershed Committee as a continuing intergovernmental coordinating body concerned with the Menomonee River watershed plan adjustment and implementation.

2. Adopt the recommended Menomonee River watershed plan as a guide to the future development of the community as that plan affects each community.

3. Adopt the regional land use and transportation plan.

4. Amend existing or adopt new local zoning ordinances so as to provide land use regulations similar to those contained in the SEWRPC Model Zoning Ordinance and adopt changes to the zoning district maps, as appropriate, to reflect the recommended land use plan element of the Menomonee River watershed plan. Such regulations should include provisions for the discontinuance of nonconforming uses in the floodways of the watershed.

5. Instruct local assessors that tax relief is available for owners of land zoned for agricultural and conservancy use in accordance with the recommended Menomonee River watershed plan.

6. Amend or adopt land division ordinances, as appropriate, prohibiting further land division and development in the floodways and floodplains of the perennial channel system of the Menomonee River watershed and assuring park plan dedication or fees in lieu of dedication.

7. Prepare and adopt or amend official maps showing, as appropriate, park and parkway land use plan elements.

8. Include floodway, floodplain, and floodproofing regulations in local building, housing, subdivision, and sanitary ordinances.

9. Consider and give due weight to the rational urban service areas implied in the Menomonee River watershed plan in all deliberations concerning proposed annexations, consolidations, and incorporations.

10. Empower the Underwood Sewer Commission to carry out flood damage abatement measures as recommended (City of Brookfield and Village of Elm Grove).

11. Continue to participate in the Federal Flood Insurance Program.

12. Continue to maintain and operate, and establish and operate a system of gages for the procurement of high water data throughout the watershed (Cities of Brookfield, Mequon, and Milwaukee, and the Villages of Elm Grove, Germantown, and Menomonee Falls).

13. Abandon, when feasible, existing municipal sewage treatment facilities (Villages of Butler, Germantown, and Menomonee Falls).

14. Work with the Milwaukee-Metropolitan Sewerage Commissions and the Department of Natural Resources in eliminating flow relief devices (Cities of Brookfield, Milwaukee, Wauwatosa, and West Allis, and the Village of Menomonee Falls).

15. Provide sanitary sewer service to areas served by onsite sewage disposal systems and all planned urban development (Cities of Brookfield, Mequon, and Milwaukee and the Villages of Germantown and Menomonee Falls and the Towns of Brookfield, Germantown, and Richfield).

16. Assist the county park and planning agencies in the acquisition and removal of structures located in the floodplain of the Menomonee River and its major tributaries (Cities of Brookfield and Wauwatosa).

17. Acquire and remove structures located in the floodplain of the Menomonee River to reduce flood damages and provide for local park expansion (City of Wauwatosa).

18. Assume responsibility for the capital cost and operation and maintenance costs of storm water pumping stations and backwater gates and other storm water control facilities as needed to supplement the channelization and dikes and floodwalls to be constructed along the Menomonee River (City of Wauwatosa).

19. Construct and maintain 6.97 miles of major channelization along the Menomonee River and Lilly Creek (Village of Menomonee Falls).

20. Work with the Milwaukee-Metropolitan Sewerage Commissions, the Underwood Sewer Commission, and the Wisconsin Department of Natural Resources to clean and maintain stream channels and hydraulic structure waterway openings.

21. Assist the county park agencies in the acquisition of selected lands lying within the primary environmental corridors of the Menomonee River and its tributaries (Cities of Brookfield and Milwaukee, Villages of Butler, Elm Grove, Germantown, and Menomonee Falls, and Town of Brookfield).

22. Approve county official maps governing park and parkway acquisition adopted pursuant to the recommendations contained herein.

23. Add erosion and sediment control requirement amendments to subdivision ordinances.

24. Examine the manner in which municipal services such as street cleaning and maintenance, street de-icing, and garbage collection are performed to determine if significant reductions can be made in the potential washoff of dust, dirt, and debris to the surface water system.

25. Develop a program combining education and regulation to: control littering by domestic animals, encourage proper application of chemical and organic fertilizers and pesticides to yards, control litter and debris and material storage on private property and in public places, and control sediment and debris during demolition and construction activities.

26. Encourage consideration by land developers of detention-retention storage.

Plan Commissions of the Cities, Villages, and Towns Within the Watershed: It is recommended that the plan commissions of all cities, villages, and towns within the watershed:

1. Adopt the watershed plan elements and certify such adoption to the governing body.

2. Formulate and recommend to their governing body amendments to their existing land use control ordinances to effectuate the land use plan elements of the watershed plan.

3. Prepare for submission to the governing body detailed local plans relative to the acquisition of primary environmental corridors.

Municipal Water and Sanitary Districts: It is recommended that all municipal water and sanitary districts within the watershed:

1. Acknowledge the recommended watershed plan, thereafter determining proper utility service areas in accordance with such plan, and adopt and adhere to utility extension policies that are consistent with the rational urban service area implied by the plan.

2. Design and install public water supply and sewerage systems so as to preclude service by such systems to proposed development located in floodplains, on soils having very severe or severe limitations for urban development, or within the recommended regional environmental corridors in prime agricultural areas.

Chapter VIII

SUMMARY AND CONCLUSIONS

INTRODUCTION

This report is one of two volumes which together present the major findings and recommendations of the Southeastern Wisconsin Regional Planning Commission Menomonee River watershed planning program. The first volume sets forth the basic principles and concepts underlying the study and presents in summary form the basic facts pertinent to the preparation of a comprehensive plan for the physical development of the Menomonee River watershed, with particular emphasis upon the existing state of the land and water resources of the basin and the developmental and environmental problems associated with these resources. The first volume also contains forecasts of anticipated future growth and changes within the watershed and an analysis of water law as such law relates to watershed plan preparation and implementation, with particular emphasis upon the legal aspects of floodland management and pollution abatement.

This, the second of the two volumes, sets forth watershed development objectives, principles, and standards; presents and compares alternative land use, floodland management, and water quality management subelements; and, drawing on those alternatives, recommends a comprehensive watershed development plan designed to meet the watershed development objectives under existing and probable future conditions. It presents a cost schedule for implementing the recommended plan over a 24-year plan implementation period and sets forth recommended means for plan implementation. In addition, this volume provides an analysis of the changes which may be expected to occur within the watershed by the year 2000 if recent development trends are allowed to continue without redirection in the public interest.

WATERSHED DEVELOPMENT OBJECTIVES

The primary objective of the Menomonee River watershed planning program is to assist the local, state, and federal units and agencies of government in abating the serious water and water resource-related problems existing within the Menomonee River basin by developing a workable plan to guide the staged development of water control facilities and related resource conservation and management programs for the watershed. The principal problems to be addressed include flood damage and water pollution, and changing land use as it relates to these two problems.

Following determination of present and probable future conditions within the watershed,[1] a framework of watershed development objectives and supporting principles and standards was established to guide the design of the alternative land use, floodland management, and water quality management plan subelements for the watershed and to provide a basis for evaluation for the relative merits of these alternative subelements. The watershed development and management objectives and supporting principles and standards set forth in this volume relate to: the adjustment of land use development to the ability of the underlying natural resource base to sustain such development without the creation of severe developmental and environmental problems; sanitary sewerage systems development; and water control facility development. All of these watershed development objectives were formulated within the context of broader regional development objectives. Briefly, this framework of watershed development objectives standards envisions a future watershed environment which is varied, safe, healthful, efficient, and aesthetically pleasing.

ALTERNATIVE PLAN SUBELEMENTS

In the preparation of the comprehensive plan for the physical development of the Menomonee River watershed, a concerted effort was made to offer for public evaluation a full range of physically feasible alternative plan subelements which might resolve existing water resource and water resource-related problems and prevent future development of such problems within the framework of the adopted watershed development objectives and supporting standards. Each alternative plan subelement was evaluated insofar as possible in terms of technical and economic feasibility, likely environmental impact, financial and legal feasibility, and public acceptability and with respect to the satisfaction of the watershed development objectives.

Alternative Land Use Plan Subelements

The recommended overall land use plan for the Menomonee River watershed is set within the context of and reflects the concepts contained in the revised and updated regional land use plan for the year 2000. The land use base subelement, which was considered as a "given" under the watershed planning program, envisions the modification of land use development trends within the Region and the watershed in order to meet stated development objectives. In the adaptation of the regional land

[1] *The reader may at this point wish to review Chapter XI, "Summary," of Volume 1 of this report, which summarizes the inventory, analysis, and forecast findings of the study, describing qualitatively and quantitatively the resource-related problems of the Menomonee River watershed that require attention. The comprehensive watershed development plan recommended in this volume is addressed to the resolution of those problems.*

use plan to the Menomonee River watershed, three alternative primary environmental corridor subelements and three alternative parkway drive-scenic drive-recreational trail subelements were considered.

With respect to protection of the 14.7 square miles of primary environmental corridor within the watershed, the three alternatives were:

- A minimum protection alternative which would rely solely on land use controls to protect those primary environmental corridor areas not already protected by virtue of public outdoor recreation and related use. In addition, this subelement calls for the application of sound management techniques to all significant woodland, wetland, and wildlife habitat areas contained within the primary environmental corridors.[2]

- An intermediate protection alternative which would incorporate selective public acquisition of the highest value corridor lands in combination with land use controls to supplement the protection afforded by the existing public and private ownership. In addition, this alternative calls for the application of sound management techniques to all significant woodland, wetland, and wildlife habitat areas contained within the primary environmental corridors.

- A maximum protection alternative which would call for public acquisition of all remaining primary environmental corridor lands not already in public or private ownership for outdoor recreation or related open space use. In addition, this alternative includes the application of sound management techniques to all significant woodland, wetland, and wildlife habitat areas contained within the primary environmental corridors.

With respect to the parkway drive-scenic drive-recreational trail subelement of the land use plan, the three alternatives considered were:

- A parkway drive-scenic drive alternative consisting of continuous system of 16.0 miles of existing parkway pleasure drives and 19.5 miles of new parkway pleasure drives, 13.2 miles of scenic pleasure drive routed over existing rural roads, and 7.4 miles to existing interconnecting urban streets. The proposed new drives would cost an estimated $3.25 million to construct.

- A recreational trail-scenic drive alternative consisting of a continuous system of 16.0 miles of existing parkway pleasure drives, 18.4 miles of new recreational trails, 2.3 miles of existing recreational trails, 13.2 miles of scenic pleasure drives routed over existing rural roads, and 6.9 miles of interconnecting existing urban streets. The proposed new recreational trails would cost an estimated $0.66 million to construct.

- A parkway drive-scenic drive-recreational trail alternative consisting of a continuous system of 16.0 miles of existing parkway pleasure drives, 13.2 miles of new parkway pleasure drives and 5.2 miles of new recreational trails, 2.3 miles of existing recreational trails, 13.2 miles of scenic pleasure drives routed over existing rural roads, and 6.9 miles of existing urban streets. The proposed new parkway pleasure drives and recreational trails would cost an estimated $2.35 million to construct.

Alternative Floodland Management Subelements

The floodland management element is the second of the three elements comprising the recommended plan for the Menomonee River watershed. The available floodland management measures from which the floodland management plan element was synthesized under the watershed planning process may be broadly subdivided into two categories: structural measures and nonstructural measures. A total of five structural floodland measures were identified for possible application, either individually or in various combinations, to specific flood-prone reaches of the watershed: 1) floodwater storage facilities, 2) floodwater diversion facilities, 3) dikes and floodwalls, 4) major channel modifications, and 5) bridge and culvert modification or replacement. The 10 nonstructural measures identified for possible inclusion in the floodland management element consist of: 1) reservation of floodlands for recreational and related open space uses, 2) floodland regulations, 3) control of land use outside of the floodlands, 4) flood insurance, 5) lending institution policies, 6) realtor policies, 7) community utility policies, 8) emergency programs, 9) structure floodproofing, and 10) structure removal.

Portions of the Menomonee River, the Little Menomonee River, Underwood Creek, Butler Ditch, and Lilly Creek within the Villages of Elm Grove and Menomonee Falls and the Cities of Brookfield, Wauwatosa, Mequon, and Milwaukee were identified as being the most flood-prone reaches in the Menomonee River watershed. Various combinations of structural and nonstructural management measures were evaluated for each of these reaches, resulting in the selection of a compatible combination of measures for each reach for inclusion within the watershed plan.

Included within the development of the floodland management plan element was an analysis of the impact of possible future land use and floodland development conditions in the watershed on flood flows, flood stages, and flood damages along the stream system. This analysis

[2] *It is important to recognize that the effectiveness of each of those three primary environmental corridor protection alternatives is based in part on the assumption that privately owned lands currently used for recreation and related open space uses will continue to be used for such purposes. If any of these alternatives was selected for implementation, local communities could help to assure such continued use by the careful application of recreational and conservancy zoning.*

indicated that, whereas implementation of the land use plan element would result in minimal aggravation of existing flood problems, the continuance of urban sprawl into the floodland and nonfloodland portions of the watershed could result in dramatic increases in flood flows, stages, and monetary damages.

In addition to determining the applicability of the various structural and nonstructural floodland management measures to the watershed, the plan preparation process included examination of accessory floodland management measures to meet special needs within the watershed. Accessory floodland management measures that were considered included the desirability of maintaining a skeleton stream gaging network in the watershed, the need for periodic cleaning and maintenance of the channel system and bridge and culvert waterway openings, and examination of means of resolving the residual flood damage problem that exists within and immediately upstream of the Menomonee River industrial valley.

Alternative Water Quality Management Subelements

Preparation of the water quality management plan element—the third of the three elements comprising the recommended Menomonee River watershed plan—emphasized refinement and extension of water quality recommendations made under other Commission studies. Development of the water quality management plan element included an evaluation of the expected impact on the watershed surface water system of pollution abatement measures recommended under the adopted regional sanitary sewerage system plan, including abandonment of all existing municipal sewage treatment plants in the watershed, abatement of combined sewer overflows, elimination of flow relief devices, and provision of sanitary sewer service to existing unsewered urban development and to planned urban development.

Three alternative measures were examined for resolution of the residual creosote pollution problem in the Little Menomonee River including: 1) a minimum disturbance approach, in which a "sweeper" unit would remove a mud-creosote-water slurry from the channel bottom, pass it through a settling and filtering treatment process, and return the creosote-free water to the stream; 2) an alternative whereby the creosote-laden bottom muds would be removed from the channel and replaced with clean material; and 3) an alternative consisting of excavating a new channel parallel to the existing channel and filling the existing channel with the excavated material thereby covering up the creosote laden-bottom muds.

The likely impact of land management measures intended to control diffuse source pollution in both rural and urban areas was determined during preparation of the water quality management plan element as was the desirability of maintaining a skeleton water quality monitoring program. The effect of pollution abatement measures on stream water quality during low flow conditions was evaluated as was the expected impact of various pollution abatement measures on the full spectrum of flow conditions likely to be expected in the surface water system in the Menomonee River watershed.

RECOMMENDED WATERSHED PLAN

Alternative plan subelements were evaluated individually in various compatible combinations and, as a result, a comprehensive watershed plan was synthesized consisting of a land use element, a floodland management element, and a water quality management element. The resultant comprehenisve watershed development plan, which is recommended for adoption as a guide for the physical development of the Menomonee River watershed and which has been formulated after a series of public informational meetings and public hearing, contains the following salient proposals.

Land Use Plan Element

The recommended land use plan element for the Menomonee River watershed consists of an overall land use plan subelement, a primary environmental corridor subelement, and a parkway drive-scenic drive-recreational trail subelement. More specifically, the recommended land use plan element proposes the following measures:

- Implementation of the controlled existing trend and 1990 land use plan originally adopted by the Commission for the Region as a whole in 1966, as re-evaluated and refined for the year 2000 by the Commission in 1976. This land use plan subelement is shown on Map 56 and envisions the use of public land use regulation and public land acquisition to guide and shape the development of a land use pattern within the watershed which would meet existing and future needs for the various land uses with a minimal deteriorating effect on the underlying and supporting natural resource base. The land use plan subelement is designed to meet the adopted regional and watershed development objectives and, thereby, achieve a safer, more healthful, attractive, and efficient land use pattern, while meeting the gross land use demands generated by the forecast population and employment levels within the watershed by the year 2000. The land use base of the watershed emphasizes the efficient provision of utility services, the attainment of cohesive urban development on appropriately suitable soils, preservation of prime agricultural lands, preservation of unique natural resources areas, and protection of floodland areas from further encroachment by urban development. The recommended overall land use base for the watershed proposes to accommodate the anticipated growth in population and employment by the conversion of approximately 15 square miles of land from rural to urban use over the next two or three decades and proposes to preserve 34 square miles of agricultural land in permanent agricultural use.

- Protection of the 14.7 square miles of net primary environmental corridors in the watershed, as shown on Map 56, through the following combination of measures contained within the intermediate primary environmental corridor protection subelement: 1) maintenance of 5.2 square miles of existing public and private outdoor recreation and open space lands in recreational use; 2) public acquisition of 6.3 square miles of selected high value primary environmental corridor lands located primarily along the main stem of the Menomonee River in Waukesha and Washington Counties, supplemented by additional acquisitions consisting largely of a portion of the Little Menomonee River primary environmental corridor, Tamarack Swamp, and two portions of the Brookfield Swamp; 3) use of public land use controls to protect the remaining 3.2 square miles of primary environmental corridor; and 4) application of sound woodland, wetland, and wildlife habitat management techniques to all 14.7 square miles of primary environmental corridor lands in the watershed. It is important to recognize that the effectiveness of the recommended primary environmental corridor plan element is based in part on the assumption that privately owned lands currently used for recreation and related open space uses will continue to be used for such purposes. It is recommended that local communities help to assure such continued use by the careful application of recreational and conservancy zoning. While such zoning is not an absolute guarantee that the lands concerned will remain permanently in recreation and open space use, the application of recreational and conservancy zoning will require formal action should a change in use be proposed by the private owners and provide an opportunity for public acquisition.

- Development of a parkway drive-scenic drive-recreational trail system to provide a means whereby the resident population of the watershed and of the Region can gain access to and fully enjoy the remaining natural resources features and outdoor recreation and related open space areas of the watershed. More specifically, this recommended subelement, as shown on Map 56, consists of an interconnected system of parkway drives and recreational trails having a total length of 56.8 miles, of which 16.0 miles would consist of existing parkway pleasure drives, 13.2 miles of new parkway pleasure drives, 2.3 miles of existing recreational trail, 5.2 miles of new recreational trail, 13.2 miles of scenic pleasure drives routed over existing roads, and 6.9 miles of existing urban streets.

Floodland Mangement Plan Element

The recommended floodland management plan element for the Menomonee River watershed consists of a carefully selected combination of structural and nonstructural measures. More specifically, the recommended floodland management plan element proposes the following measures:

- Recognition that the underlying and most critical floodland management measure is the overall land use plan for the watershed. Analyses conducted under the watershed planning program clearly indicate that the severity of flood problems and the magnitude of the associated monetary flood losses in the basin may be expected to be very sensitive to decisions concerning future land use development both within and outside of the watershed floodlands.

- Implementation of a primarily structural floodland management subelement for the City of Brookfield, as shown on Map 29 of this volume, consisting of the following three components: 1) a 215 acre-foot detention storage reservoir located upstream on Dousman Ditch in the City of Brookfield; 2) replacement of the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge over Underwood Creek; and 3) the floodproofing of up to 65 structures and the removal of approximately seven structures along the reach of Underwood Creek bounded at the upstream end by the railroad at the downstream end by North Avenue. In addition, this subelement recommends that floodproofing of 20 structures be used to resolve existing and probable future flood problems along the 1.26-mile-long reach of Butler Ditch upstream of Lisbon Road within the City of Brookfield as shown on Map 26 of this volume.

- Implementation of a floodland management subelement for the Village of Elm Grove, as shown on Map 55 of this volume, consisting of two components: 1) a 215 acre-foot flood detention reservoir located upstream of the Village on Dousman Ditch in the City of Brookfield; and 2) floodproofing of up to 187 structures and the removal of one structure located along the Underwood Creek reach within the Village.

- Implementation of a primarily structural floodland management element for the reach of the Menomonee River in the City of Wauwatosa between the eastern limits of the City and Harwood Avenue, as shown on Map 53 of this volume, consisting of two components: 1) 1.65 miles of major channelization supplemented with low dikes and floodwalls along the Menomonee River from the N. 70th Street bridge, in the City of Wauwatosa downstream to the N. 45th Street bridge in the City of Milwaukee and 2) acquisition and removal of approximately 61 structures along the Menomonee River immediately upstream of the N. 70th Street bridge and floodproofing of up to 93 structures in that area as shown on Map 35. The structure floodproofing and removal component of this alternative would permit a 13 acre expansion of Hart Park in the City of Wauwatosa and would permit retention of natural features of the Menomonee River in the "Old Village area" and immediate environs, all consistent with redevelopment and revitalization proposals being considered by the City for that area. In addition, it is recommended that the floodproofing of up to 211 structures and the removal of approximately nine structures, as shown on Map 32 of this volume, be used to resolve existing and probable future flood problems along the Menomonee River between Harwood Avenue and W. Hampton Avenue in the City of Wauwatosa. This subelement also recommends, as shown on Map 32 of this volume, that the floodproofing of up to 56 structures be used to resolve existing and probable future flood problems in the City of Wauwatosa along Underwood Creek between the Menomonee River and the Zoo Freeway and that the floodproofing of up to 13 structures be used to resolve existing and probable future flood problems in the City of Wauwatosa along Honey Creek between the Menomonee River and W. Wisconsin Avenue.

- Floodproofing of up to 19 structures, as shown on Map 36 of this volume, to resolve existing and probable future flood problems along the Little Menomonee River in the City of Mequon immediately north of Mequon Road.

- Floodproofing of up to 69 primarily commercial structures, as shown on Map 54 of this volume, to resolve, in combination with the channel modifications extending downstream through this reach from the City of Wauwatosa, the existing and future flood problems along the 0.7 miles long reach of the Menomonee River in the City of Milwaukee between N. 45th Street and N. 60th Street extended.

- Implementation of structural floodland management measures for the Menomonee River and Lilly Creek in the Village of Menomonee Falls, as shown on Map 31 of this volume, consisting of three components: 1) 1.35 miles of major channelization along the Menomonee River from the Washington-Waukesha County line downstream to the Menomonee Falls Dam, 2) 3.25 miles of major channelization along the Menomonee River from Arthur Avenue downstream to the Waukesha-Milwaukee County line, and 3) 2.97 miles of major channelization along Lilly Creek from Silver Spring Drive downstream to the Menomonee River.

- Replacement or modification of 48 bridges and culverts on the major stream system of the Menomonee River watershed, as listed in Table 33, which have inadequate hydrologic-hydraulic capacity as manifested by overtopping of the approach road or of the structure itself during specified major flood events, so as to eliminate interference with the desirable operation of the highway and railroad transportation system. This replacement or modification would be gradually accomplished as river crossings are replaced or modified for transportation system improvement or maintenance purposes.

- The design of all new or replacement river crossings within the watershed so as to satisfy the applicable objectives and standards adopted under the study. Of particular importance is the standard which requires that all new and replacement crossings be designed so as to accommodate 100-year recurrence interval flood events under year 2000 plan conditions without raising the peak discharge more than 0.5 feet above the peak stage for the 100-year recurrence interval flood as established in the watershed plan.

- Modification of existing floodland and related regulations or preparation of new such regulations by the following communities based upon the new flood hazard data and the floodland management concepts and recommendations set forth in this report: the Cities of Brookfield, Mequon, Milwaukee, Wauwatosa, West Allis, and Greenfield and the Villages of Elm Grove, Germantown, Menomonee Falls, and Butler. The floodland and related regulations developed by the above communities for the Menomonee River watershed should be explicitly designed to complement the recommended land use plan element—this is particularly important for the primary environmental corridor protection subelement of that plan—including use of the regulations to provide interim control over primary environmental corridor lands recommended for eventual acquisition. Map 42 in this volume shows the overall manner in which floodland regulations are proposed to be applied to the watershed stream system. This reach-by-reach indentification of the recommended approach to floodland regulations is intended to identify those portions of the watershed in which floodland regulations should be designed to preserve in essentially open, natural conditions all of the floodland areas, as opposed to those portions of the watershed in which floodland regulations must reflect the reality of existing urban development through the use of a two-district floodway-floodplain approach. Of the approximately 72 miles of watershed stream system for which the preparation and adoption of floodland regulations are recommended in the watershed plan, about 56 miles would be subjected to regulations intended to preserve in essentially natural, open use all of the 100-year floodlands under year 2000 conditions. The remaining 16 miles would be subjected to regulations intended to recognize the commitment to urban development that already exists while preserving a sufficient floodway area to provide for the safe conveyance of the 100-year recurrence interval flood flow.

- Application of land use controls outside of the floodlands because of the demonstrated hydrologic-hydraulic impact of land use outside of the floodlands on the extent and severity of flood problems within the floodlands. Such land use controls may take the form of appropriate amendments of zoning, land subdivision, and sanitary and building ordinances adopted by counties, cities, villages, and towns.

- Continuation of the significant steps that have already been taken by watershed communities towards participation in the federal flood insurance program in the form of authorization by the U.S. Department of Housing and Urban Development, in cooperation with the Wisconsin Department of Natural Resources, of insurance rate studies in the Cities of West Allis and Mequon and the Villages of Germantown and Elm Grove. It is further recommended that contractors retained by the U.S. Department of Housing and Urban Development to conduct the flood insurance rate studies base those studies on the flood hazard data developed under the watershed program. Finally, the watershed plan recommends that owners of property and flood-prone areas purchase flood insurance so as to provide some financial relief for losses incurred in future floods.

- Continuation by lending institutions of the policy of determining the flood-prone status of properties prior to granting of a mortgage. It is further recommended that the principal source of flood hazard information be that developed under the watershed planning program.

- Continuation of the policy by real estate brokers, salesmen and their agents to inform potential purchasers of property of any flood hazard which may exist at the site. It is further recommended that the principal source of flood hazard information be that developed under the watershed planning program.

- Adoption of policies by governmental units and agencies having responsibility for public utilities and facilities—such as water supply, sewerage, streets, and highways—that complement the floodland management recommendations for the Menomonee River watershed as well as the recommended primary environmental corridor protection subelement.

- Development of emergency procedures by watershed communities to provide floodland residents and other property owners with information about floods already in progress. The flood information procedures for particular communities might be selected from the following: monitoring of National Weather Service broadcasts during periods that rainfall or snowmelt are occurring or anticipated, patrolling riverine areas to detect rising stages and bankfull conditions, emergency messages broadcast over local radio and television stations, use of police patrol cars or other vehicles equipped with public address systems, and use of warning sirens particularly during nighttime hours.

- Maintenance of a basic stream gaging network within the watershed consisting of: 1) continued operation of two continuous recorder gages that were temporarily installed for purposes of the International Joint Commission Menomonee River Pilot Watershed study at the N. 70th crossing of the Menomonee River in Wauwatosa and the Pilgrim Road crossing of the Menomonee River in the Village of Menomonee Falls; 2) continued operation of two of the three partial record stations operated in the basin by the U.S. Geological Survey in cooperation with the Wisconsin Departments of Transportation and Natural Resources—the Freistadt gage on the Little Menomonee River and the Milwaukee gage on Honey Creek; 3) continued maintenance of crest stage or staff gage networks by the Village of Menomonee Falls, the City of Milwaukee, and the Milwaukee-Metropolitan Sewerage Commissions; and 4) establishment and maintenance of crest stage or staff gage networks by the Cities of Mequon and Brookfield and the Villages of Germantown and Elm Grove as shown on Map 44 of this volume.

- Consideration by research institutions having responsibilities in water resource and water resource-related areas of the development of research projects, educational programs, and other special studies that could incorporate portions of the existing and extensive water quality-quantity monitoring network that has been temporarily established within the watershed for purposes of the IJC Menomonee River Pilot watershed study.

- Establishment of a new flood protection elevation at least two feet above the 100-year recurrence interval peak flood stage profile under the year 2000 land use plan conditions along the Menomonee River in the industrial valley upstream of approximately the 27th Street viaduct.

- Consideration of the removal of The Falk Corporation dam in order to reduce flood stages at the earthen dike protecting the south boundary of the Chicago, Milwaukee, St. Paul, and Pacific Railroad yard. In the event that The Falk Corporation dam is retained, the dike protecting the railroad yard should be raised by up to two feet.

- Addition of a vertical extension to the flood walls along the east bank of the Menomonee River between IH 94 and the W. Wisconsin Avenue viaduct; on the west bank of the Menomonee River between the W. Wisconsin Avenue viaduct and the Chicago, Milwaukee, St. Paul, and Pacific Railroad; and along all or portions of both sides of the Menomonee River between the Chicago, Milwaukee, St. Paul, and Pacific Railroad bridge and the N. 45th Street crossing of the River as shown on Map 45 of this volume.

- Establishment of a program to carry out periodic cleaning and maintenance of both stream channels and of the bridge and culvert waterway openings by those civil divisions and governmental units within the watershed affected by or having jurisdiction over the watershed stream system.

Water Quality Management Plan Element

The recommended plan proposes the abatement of surface water pollution problems within the Menomonee River watershed through the following measures:

- Abandonment of the four remaining municipal sewage treatment plants in the watershed—the Village of Germantown Old Village plant, the Village of Menomonee Falls Pilgrim Road and Lilly Road plants, and the Village of Butler overflow-chlorination facilities—and the connection of the tributary service areas to the Milwaukee Metropolitan system through completion of the remaining segments of the recommended inter-community trunk sewer system as shown on Map 52 of this volume.

- Implementation, through construction of the necessary facilities, of the recommendations contained within the preliminary engineering study currently being conducted by the Milwaukee-Metropolitan Sewerage Commissions concerning the abatement of combined sewer overflows in the lower reaches of the Menomonee River, Milwaukee River, and Kinnickinnic River watersheds, insofar as those recommendations are consistent with the objectives established under the Menomonee River watershed plan and the regional sanitary sewerage system plan.

- Gradual elimination through trunk and relief sewer construction and other measures within the framework of the recently instituted Wisconsin Pollutant Discharge Elimination System, of approximately 102 sanitary sewer system flow relief devices—crossovers, bypasses, and relief pumping stations—discharging directly or indirectly to Menomonee River and tributaries during wet weather.

- Gradual elimination of the 44 industrial discharges to the Menomonee River and its tributaries under provisions contained within the Wisconsin Pollutant Discharge Elimination System.

- Abatement of the residual creosote pollution problem in a 3.46 mile reach of the Little Menomonee River within Milwaukee County by excavation of a new parallel channel, filling the existing channel, and restoring the site as shown on Map 46 of this volume. This would yield a significant reduction in creosote exposure and in attendant health and safety hazard to people and aquatic flora and fauna.

- Provision of sanitary sewer service to approximately 12 square miles of presently unsewered urban development within the watershed and to approximately 15 square miles of new urban development anticipated between now and the year 2000 in accordance with the recommended land use plan for the watershed as shown on Map 56.

- Implementation of the following land management measures to effect a significant reduction in the washoff of pollutants from the approximately 36 square miles of crop and pasture land as shown on Map 52: contour plowing, strip cropping, and minimum tillage supplemented with the judicious application of other measures including bench terraces.

- Abatement of pollution caused by washoff from about 40 barnyards and feedlots in the watershed through construction of feedlot runoff pollution control systems consisting primarily of drainage control around each feedlot and provision of manure storage and handling facilities.

- Implementation of the following land management measures to effect a significant reduction in the washoff of pollutants from approximately 67 square miles of urban land surface as shown on Map 52: control of littering by domestic animals; proper application of chemical and organic fertilizers and pesticides to lawns; control of litter and debris and proper material storage on private property and at public places; control of sediment and debris during demolition and construction activities; improvements in provision of municipal services such as street cleaning and maintenance, street de-icing, and garbage collection; and use of detention-retention storage for control of storm water runoff from new urban development.

- Incorporation into the water quality management plan element of the water quality monitoring program recommendations being developed under the areawide water quality planning and management program.

ACHIEVEMENT OF OBJECTIVES AND STANDARDS

In its most basic sense, planning is a rational process for establishing and meeting objectives. The objectives and supporting standards adopted for the Menomonee River watershed constitute the overall goals of the comprehensive plan, and the degree to which those objectives and standards are likely to be satisfied provides a measure of the success of the plan preparation process. Accordingly, an evaluation was conducted of the comprehensive plan based on its ability to meet the watershed development objectives and standards.

Of the 68 applicable supporting standards, 32, or 47 percent, would be fully satisfied assuming implementation of the watershed plan. Another 28, or 41 percent, could be met by careful detailed design during plan implementation. Eight standards, or 12 percent of the total number of applicable standards, were rated as "partially met" or "cannot be met." The relatively small number of standards that cannot be met or can only be partially met under the recommended comprehensive plan for the Menomonee River watershed support objectives that are inextricably related to the underlying natural resource base; failure to fully meet those standards reflects the already deteriorated condition of the underlying natural resource base of this urbanizing watershed.

In summary, the recommended comprehensive plan for the Menomonee River watershed could result in substantial achievement of the adopted watershed development objectives and standards; as a result, implementation of the plan may be expected to provide a safer, more healthful, and more attractive and pleasant, as well as a more orderly and efficient environment for all forms of life in the watershed.

CONSEQUENCES OF NOT IMPLEMENTING THE RECOMMENDED PLAN

The recommended comprehensive plan for the Menomonee River watershed provides, within the framework of the adopted watershed development objectives and standards, the best combination of measures for resolving such water resource and water resource-related problems as flooding, water pollution, diminishing quality of the natural resource base, and changing land use that presently plague the watershed or may be expected to do so in the future. In the absence of such a sound comprehensive plan, a multitude of incorrect decisions may be made and courses of action are likely to be followed that will lead to the aggravation of existing water resource and water resource-related problems as well as the development of new problems. Accordingly, an analysis was conducted to identify and, where feasible, to quantify the likely consequences of not adopting and implementing the recommendations contained within the watershed plan. This analysis of negative consequences was intended primarily to support and reinforce the need for implementing the recommended rational, long-range, comprehensive plan for the urbanizing Menomonee River watershed.

Likely consequences of not implementing the recommended comprehensive plan for the Menomonee River watershed include:

- Increased costs of public utilities and services such as sanitary sewerage, water supply, transportation, and police and fire protection attendant to the highly diffused, low to medium density urban development that is likely to occur as a result of failure to implement the overall land use plan.
- Up to a six-fold increase in peak flood discharges, up to a nine foot increase in peak flood stages, and up to an approximately four-fold increase in average annual flood losses to existing flood-prone development as a result of failure to implement the overall land use plan.
- Loss of the recreational, aesthetic, ecologic and cultural values found in essentially natural, riverine lands and associated woodland, wetland, and wildlife habitat areas as a result of the failure to implement the primary environmental corridor protection recommendations.
- Widespread encroachment of urban development into riverine lands that are wet, flood-prone, and otherwise unsuited for such development as a result of failure to retain in compatible open space use riverine areas that are unoccupied by urban development and not committed to such development.
- Lack of convenient public access to and use of riverine open space lands as a result of failure to implement the recommended parkway drive-scenic drive-recreational trail system.
- Continuation of average annual flood damage risks of $600,000 per year or more for six communities within the watershed as a result of failure to implement the recommended primarily structural flood control measures.
- Continued and increased interference with the safe and efficient operation of highway and railroad facilities during flood events as a result of failure to implement the bridge replacement and bridge design recommendations contained within the watershed plan.
- Incurrence of high monetary flood losses by owners of flood-prone structures and property as a result of failure to participate in the federal flood insurance program.
- Acquisition by flood-prone lands and structures by unwary buyers as a result of failure to continue the desirable lending institution and realtor policies concerning the full disclosure of the flood vulnerability riverine area land structures.
- Encroachment of urban development into flood-prone lands and into primary environmental corridors as a result of the failure of individual communities to adopt utility policies in conformance with floodland management and primary environmental corridor measures contained within the watershed plan.
- Incurrence of unnecessary damage to property as well as unnecessary risks to the safety and well being of property owners as a result of failure by flood-prone communities to adopt emergency measures to be invoked during the flood events.

- Loss of the opportunity to monitor the effects of future urbanization in the watershed and to ultimately refine the simulation modeling as a result of failure to implement the stream gaging recommendations.

- Risk of damage to high value industrial-commercial lands and temporary disruption of production and full scale employment within the Menomonee River industrial valley and environs as a result of the failure to implement the miscellaneous measures recommended under the floodland management element for the Menomonee River industrial valley.

- Large nutrient loads to the surface waters producing nuisance growths of algae and aquatic plants and oxygen depletion as a result of failure to complete trunk sewers needed to permit abandonment of municipal sewage treatment plants, to abate combined sewer overflows, to eliminate flow relief devices, and to implement land management practices.

- Public health hazards including risk of contacting toxic materials and infectious diseases as a result of failure to abate combined sewer overflow, eliminate flow relief devices and industrial discharges, provide sanitary sewer service to existing unsewered urban development and to new urban development, abate creosote pollution, and implement land management practices.

- Input of organic materials and resulting dissolved oxygen depletion and interference with maintenance of warm water fishery as a result of failure to eliminate municipal sewage treatment plants and implement land management practices.

COST ANALYSIS

In order to assist public officials in evaluating the recommended comprehensive Menomonee River watershed plan, a preliminary capital improvement program with attendant operation and maintenance costs was prepared which, if followed, would result in total watershed plan implementation by the year 2000. Capital costs and operation and maintenance expenditures assigned to the Menomonee River watershed plan exclude the cost of pollution abatement measures recommended in the adopted regional sanitary sewerage system plan for implementation within the Menomonee River watershed since these costs were included in the sewerage system plan.

The preliminary capital improvement program includes the staging of the necessary land acquisition and facility construction and the distribution of the attendant costs including operation and maintenance expenditures over a 24-year period. This expenditure program is presented in summary form for the watershed as a whole in Table 47 and is presented in more detailed form by county and selected civil division in a series of tables in Chapter VII of this volume. The ultimate adoption of capital improvement programs for implementation of the watershed plan will require a *determination* by the responsible public officials not only of those plan subelements which are to be implemented, and the timing of such implementation, but also of the principal beneficiaries and available best means of financing.

The full capital investment and operation and maintenance costs of implementing the recommended comprehensive plan for the Menomonee River watershed are estimated at $36.0 million over the 24-year plan implementation period. Of this total cost, about $10.6 million, or about 29 percent, is required for implementation of the recommended land use plan element which, more specifically, includes the primary environmental corridor protection subelement and the parkway drive-scenic drive-recreational trails subelement. About $14.3 million, or about 40 percent, of the full cost associated with the watershed plan is required or implementation of the recommended floodland management element including recommended channel modification, dikes and floodwalls, detention storage, structure floodproofing and removal, bridge modification, continued operation of stream gaging network, and miscellaneous flood damage control measures in the industrial valley. About $11.1 million, or about 31 percent, of the full cost of implementing the recommended comprehensive plan is required for implementation of the creosote pollution abatement subelement and the land management subelement of the recommended water quality management element.

The average annual cost of the total capital investment and operation and maintenance costs required for plan implementation would be approximately $1.50 million, or about $4.08 per capita per year over the 24-year plan implementation period. The average annual cost of implementation of the land use plan element, the floodland management plant element, and the water quality management plan element, and the water quality management plan element, respectively, is about: $440,300, or about $1.20 per capita; $596,400, or about $1.62 per capita; and $463,700, or $1.26 per capita.

In order to assess the possible impact of implementation of the watershed plan on the public financial resources of local units of government within the watershed, an analysis was made of the recent public expenditures for park and outdoor recreation purposes and for major channel modifications for comparison to the cost associated with the recommended comprehensive plan for the watershed. Recent capital and operation and maintenance expenditures for park and outdoor recreation purposes were used as an index of the ability of local units of government to expend the funds necessary to implement the primary environmental corridor subelement and the parkway drive-scenic drive-recreational trails subelement of the land use plan element. Similarly, recent capital expenditures for major channel works were used as an index of the ability of local units of government to expend the funds necessary to implement the structural flood control measures contained within the recommended floodland management plan element of the watershed plan. Most of the water quality management subelements recommended under the Menomonee River watershed planning program were previously recommended under the adopted regional sanitary sewerage system plan and, under that planning program, analyses were conducted to demonstrate that sufficient funds would be available to implement the recommended pollution abatement measures.

It may be concluded that sufficient monies to implement the recommended land use plan element, floodland management plan element, and the water quality management plan element of the comprehensive Menomonee River watershed should become available within the watershed. However, significant shifts may be required with respect to where within the watershed such expenditures have been made in the past relative to where they must be made in the future. The cost of implementing the watershed plan would be reasonably achievable by continuing the approximate current public expenditure patterns for park and outdoor recreation purposes, flood control, and pollution abatement. It is clear that if the adopted watershed development objectives and standards are to be met, and if the associated desired environmental quality within the watershed is to be achieved and maintained, the level of expenditures needed to implement the recommended watershed plan is necessary and fully warranted.

IMPLEMENTATION

The legal and governmental framework existing within the Menomonee River watershed is such that existing state, areawide, county, and local units of government can readily implement all the major recommendations contained in the comprehensive Menomonee River watershed plan; that is, no significant additional statutory authority, governmental agencies, or institutional arrangements are needed to implement the plan. A comprehensive, cooperative, intergovernmental plan implementation program has been prepared which indicates the specific action which will be required for each level, agency, and unit of government operating within or having responsibility within the watershed if the recommended watershed plan is to be fully implemented.

At the local level, plan implementation entities include the governing bodies of the 17 cities, villages, and towns and the four counties within the watershed and the soil and water conservation districts. At the areawide level, plan implementing entities include the Metropolitan Sewerage District of the County of Milwaukee, the Jackson-Germantown Drainage District, the Underwood Sewer Commission, and the Menomonee South Sewerage Commission. At the state level, implementing entities include the Wisconsin Departments of Natural Resources, Local Affairs and Development, Transportation, and Health and Social Services, and the Wisconsin Board of Soil and Water Conservation Districts. At the federal level, plan implementing entities include the U. S. Department of Housing and Urban Development; the U. S. Environmental Protection Agency; the U. S. Department of Interior, Bureau of Outdoor Recreation and Geological Survey; the U. S. Department of Agriculture, Agricultural Stabilization and Conservation Service and the Soil Conservation Service; and the U. S. Department of Army, Corps of Engineers.

Primary emphasis in Menomonee River watershed plan implementation is based upon actions by the Wisconsin Department of Natural Resources; Metropolitan Sewerage District of the County of Milwaukee; the four county boards of the counties of Milwaukee, Ozaukee, Washington and Waukesha; the Underwood Sewer Commission; and by individual municipal units of government.

The specific plan implementation responsibilities suggested for each level, agency, and unit of government operating within or having responsibilities within the Menomonee River watershed are set forth in the summary section of Chapter VII of this volume and in Table 48 of that chapter. In the final analysis, implementation of the recommended Menomonee River watershed plan must proceed in a comprehensive, fully coordinated fashion with the assistance and cooperation of all affected levels, units, and agencies of government within the watershed.

CONCLUSION

Although the cost may appear high for adopting and implementing the recommended comprehensive watershed plan for the Menomonee River basin and the pollution abatement measures included in the adopted regional sanitary sewerage system plan and intended for implementation, in part, within the Menomonee River watershed, the cost of not doing so is even higher. This is true measured not only in monetary terms but also in terms of an irreversible deterioration of the natural resource base and a decline in the overall quality of the environment and, hence, the overall quality of life within the watershed. Failure to act upon the plan recommendations in a timely manner will inevitably commit local units of government within the watershed to an unnecessary expenditure of large amounts of public funds for future corrective measures. If the existing trend in urbanization continues within the watershed, those subelements of the recommended plan requiring public acquisition of lands should be substantially implemented within the first 10 years of the plan design period or the opportunity to acquire these important lands may be lost for all time. If the primary environmental corridor protection recommendations and the associated recommended parkway drive-scenic drive-recreational trail system are not implemented, the watershed will incur a substantial loss of recreational, aesthetic, ecologic, and cultural values normally found in riverine lands and in associated woodland, wetland, and wildlife habitat areas. If the structural and nonstructural measures included in the floodland management element of the watershed plan are not implemented, flood damages will continue to increase with the possibility of a four-fold increase in average annual flood damages under conditions of complete urbanization of the watershed land surface. If the pollution abatement measures contained in the water quality management plan element are not implemented, surface water quality may be expected to continue to deteriorate within the watershed and the full potential for utilization will never be realized.

Time is of the essence. The urbanization process that is already underway within the watershed may be expected to continue to place intensive demands upon the limited resource base. The inevitable result will be the further intensification of existing developmental and environmental problems and the creation of new problems which will be extremely expensive to solve if, indeed, solutions will be at all possible.

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APPENDICES

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Appendix A

MENOMONEE RIVER WATERSHED COMMITTEE

Herbert A. Goetsch Chairman	Commissioner of Public Works, City of Milwaukee
J. William Little Vice-Chairman	City Administrator, City of Wauwatosa
Kurt W. Bauer Secretary	Executive Director, SEWRPC
Robert J. Borchardt	Chief Engineer and General Manager, Milwaukee-Metropolitan Sewerage Commissions
Arthur D. Doll	Director, Bureau of Planning, Wisconsin Department of Natural Resources
Glenn H. Evans	Member, Citizens for Menomonee River Restoration, Inc.
Frederick E. Gottlieb	Village Manager, Village of Menomonee Falls
Frank S. Hartay	Plant Engineer, The Falk Corporation, Milwaukee
George C. Keller	President, Wauwatosa State Bank
Raymond J. Kipp	Dean, College of Engineering, Marquette University
Thomas M. Lee	Chief, Flood Plain-Shoreland Management Section, Wisconsin Department of Natural Resources
Thomas P. Leisle	Mayor, City of Mequon; Supervisor, Ozaukee County
Robert J. Mikula	General Manager, Milwaukee County Park Commission
Thomas J. Muth	Director of Public Works, Village of Germantown
Dennis Nulph	District Engineer, Wisconsin Department of Natural Resources
Richard G. Reinders	Trustee, Village of Elm Grove
John E. Schumacher	City Engineer, City of West Allis
Walter J. Tarmann	Executive Director, Waukesha County Park and Planning Commission
Clark E. Wangerin	City Engineer, City of Brookfield

The following individuals also participated actively in the work of the Committee during preparation of the watershed plan: Robert E. Seaborn, former Plant Engineer, The Falk Corporation; William Manske, Sewer Research Engineer, Department of Public Works, City of Milwaukee; Donald G. Wieland, Director of Engineering, Milwaukee-Metropolitan Sewerage Commissions; Robert O. Hussa, Member, Citizens for Menomonee River Restoration; Irving Heipel, Landscape Architect, Milwaukee County Park Commission; Donald A. Roensch, Director of Public Works, City of Mequon; Ray D. Leary, former Chief Engineer and General Manager, Milwaukee-Metropolitan Sewerage Commissions; and Randall C. Melody, Chief Research Planner, Waukesha County Park and Planning Commission.

Appendix B

TECHNICAL ADVISORY COMMITTEE ON NATURAL RESOURCES AND ENVIRONMENTAL DESIGN

Arthur D. Doll, Chairman	Director, Bureau of Planning, Wisconsin Department of Natural Resources
Kurt W. Bauer, Secretary	Executive Director, SEWRPC
Robert W. Baker	Supervising Development Engineer, Division of Highways, Wisconsin Department of Transportation
William W. Barnwell	District Chief, Water Resources Division, U. S. Geological Survey, Madison
Edmund N. Brick	Chief, Water Regulation Section, Bureau of Water Regulation and Zoning, Wisconsin Department of Natural Resources
Thomas A. Calabresa	Chief, Private Water Supply Section, Bureau of Water Quality, Wisconsin Department of Natural Resources
Warren A. Gebert	Assistant District Chief, Water Resources Division, U. S. Geological Survey, Madison
Harlan D. Hirt	Chief, Planning Branch, Region V, Federal Water Quality Administration, U. S. Environmental Protection Agency
Jerome C. Hytry	State Conservationist, U. S. Soil Conservation Service
Elroy C. Jagler	Meteorologist in Charge, National Weather Service Forecast Office, Milwaukee
George A. James	Director, Bureau of Local and Regional Planning, Wisconsin Department of Local Affairs and Development
Leonard C. Johnson	Soil and Water Conservation Specialist, Wisconsin Board of Soil and Water Conservation Districts
James M. Maas	Chief, Planning Division, U. S. Army Corps of Engineers, Chicago
Jerome McKersie	Chief, Water Quality Evaluation Section, Bureau of Water Quality, Wisconsin Department of Natural Resources
Meredith E. Ostrom	Director and State Geologist, Geological and Natural History Survey, University of Wisconsin-Extension
Walter J. Tarmann	Executive Director, Waukesha County Park and Planning Commission
Donald G. Wieland	Director of Engineering, Sewerage Commission of the City of Milwaukee
Harvey E. Wirth	State Sanitary Engineer, Division of Health, Wisconsin Department of Health and Social Services

Appendix C

RAINFALL AND RUNOFF DATA FOR STORM WATER DRAINAGE AND FLOOD CONTROL FACILITY DESIGN

Table C-1

POINT RAINFALL INTENSITY-DURATION-FREQUENCY EQUATIONS FOR MILWAUKEE, WISCONSIN[a]

Recurrence Interval (Years)	Equation[b]: Duration of 5 Minutes or More But Less Than 60 Minutes	Equation[b]: Duration of 60 Minutes or More Through 24 Hours
2	$i = \frac{87.5}{15.4 + t}$	$i = 28.9\ t^{-0.781}$
5	$i = \frac{120.2}{16.6 + t}$	$i = 38.2\ t^{-0.776}$
10	$i = \frac{141.8}{17.1 + t}$	$i = 44.2\ t^{-0.772}$
25	$i = \frac{170.1}{17.8 + t}$	$i = 52.3\ t^{-0.771}$
50	$i = \frac{190.1}{18.0 + t}$	$i = 57.3\ t^{-0.768}$
100	$i = \frac{211.4}{18.4 + t}$	$i = 63.5\ t^{-0.768}$

[a] *The equations are based on Milwaukee rainfall data for the 64-year period of 1903 to 1966. These equations are applicable, within an accuracy of 10 percent, to the entire Southeastern Wisconsin Planning Region.*

[b] *i = Rainfall intensity in inches per hour.*
t = Duration in minutes.

Source: SEWRPC.

Table C-2

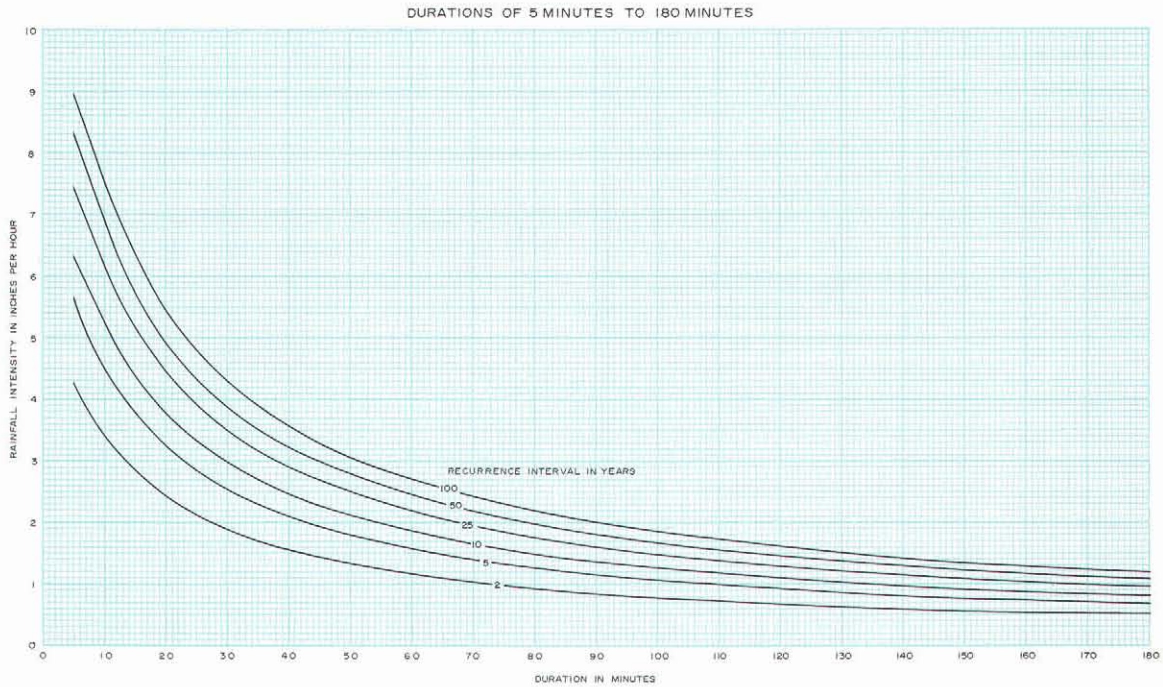
WEIGHTED RUNOFF COEFFICIENTS FOR USE IN THE RATIONAL FORMULA

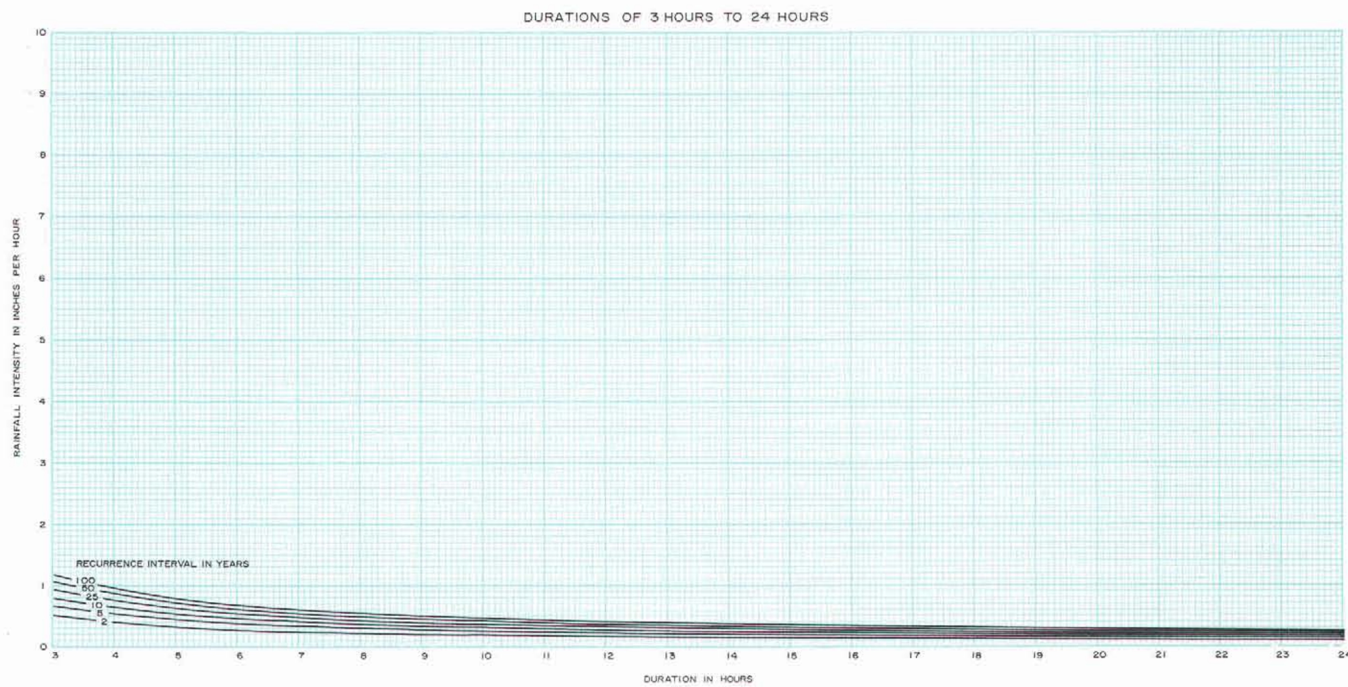
Land Use	Percent Impervious Area	A: 0 - 2	A: 2 - 6	A: 6 & Over	B: 0 - 2	B: 2 - 6	B: 6 & Over	C: 0 - 2	C: 2 - 6	C: 6 & Over	D: 0 - 2	D: 2 - 6	D: 6 & Over
		Hydrologic Soil Group											
		Slope Range (Percent)			Slope Range (Percent)			Slope Range (Percent)			Slope Range (Percent)		
Industrial.	90	0.67	0.68	0.68	0.68	0.68	0.69	0.68	0.69	0.69	0.69	0.69	0.70
		0.85	0.85	0.86	0.85	0.86	0.86	0.86	0.86	0.87	0.86	0.86	0.88
Commercial . . .	95	0.71	0.71	0.72	0.71	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
		0.88	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.89	0.89	0.90
High-Density Residential. . . .	60	0.47	0.49	0.50	0.48	0.50	0.52	0.49	0.51	0.54	0.51	0.53	0.56
		0.58	0.60	0.61	0.59	0.61	0.64	0.60	0.62	0.66	0.62	0.64	0.69
Medium-Density Residential. . . .	30	0.25	0.28	0.31	0.27	0.30	0.35	0.30	0.33	0.38	0.33	0.36	0.42
		0.33	0.37	0.40	0.35	0.39	0.44	0.38	0.42	0.49	0.41	0.45	0.54
Low-Density Residential. . . .	15	0.14	0.19	0.22	0.17	0.21	0.26	0.20	0.25	0.31	0.24	0.28	0.35
		0.22	0.26	0.29	0.24	0.28	0.34	0.28	0.32	0.40	0.31	0.35	0.46
Agriculture. . . .	5	0.08	0.13	0.16	0.11	0.15	0.21	0.14	0.19	0.26	0.18	0.23	0.31
		0.14	0.18	0.22	0.16	0.21	0.28	0.20	0.25	0.34	0.24	0.29	0.41
Open Space . . .	2	0.05	0.10	0.14	0.08	0.13	0.19	0.12	0.17	0.24	0.16	0.21	0.28
		0.11	0.16	0.20	0.14	0.19	0.26	0.18	0.23	0.32	0.22	0.27	0.39
Freeways and Expressways. . .	70	0.57	0.59	0.60	0.58	0.60	0.61	0.59	0.61	0.63	0.60	0.62	0.64
		0.70	0.71	0.72	0.71	0.72	0.74	0.72	0.73	0.76	0.73	0.75	0.78

Source: SEWRPC.

Figure C-1

POINT RAINFALL INTENSITY-DURATION-FREQUENCY CURVES FOR MILWAUKEE, WISCONSIN[a] (ARITHMETIC SCALES)



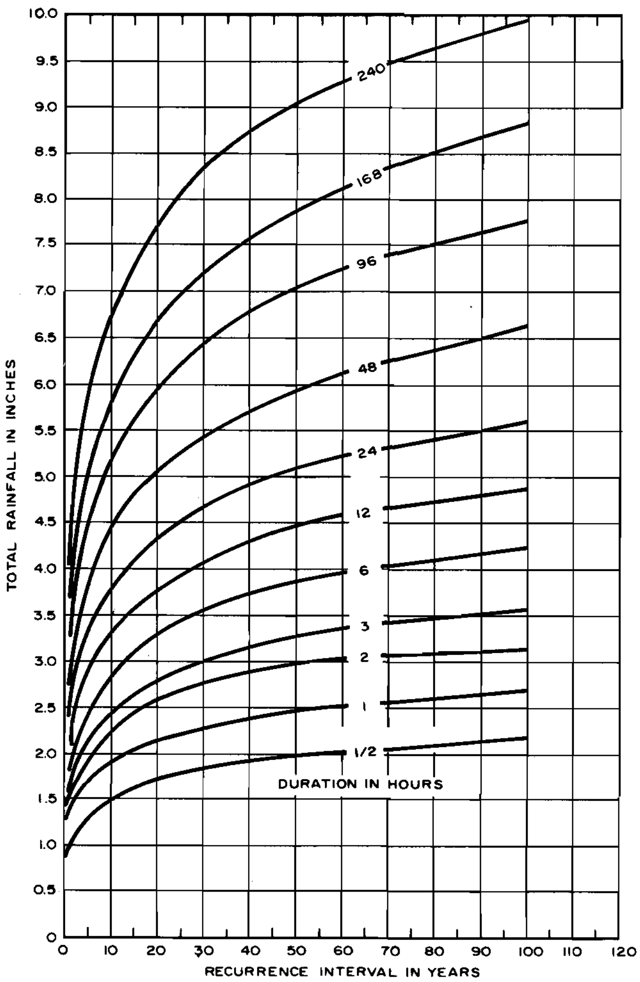


[a] *The curves are based on Milwaukee rainfall data for the 64-year period of 1903 to 1966. These curves are applicable within an accuracy of ± 10 percent to the entire Southeastern Wisconsin Planning Region.*

Source: SEWRPC.

Figure C-2

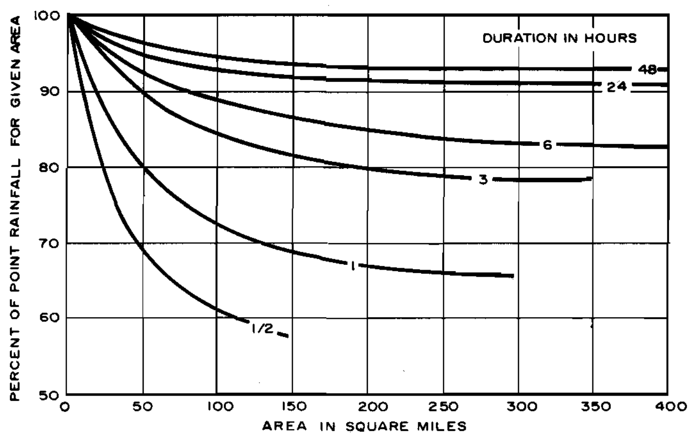
POINT RAINFALL DEPTH-DURATION-FREQUENCY RELATIONSHIPS IN THE REGION AND THE MENOMONEE RIVER WATERSHED



Source: National Weather Service and SEWRPC.

Figure C-3

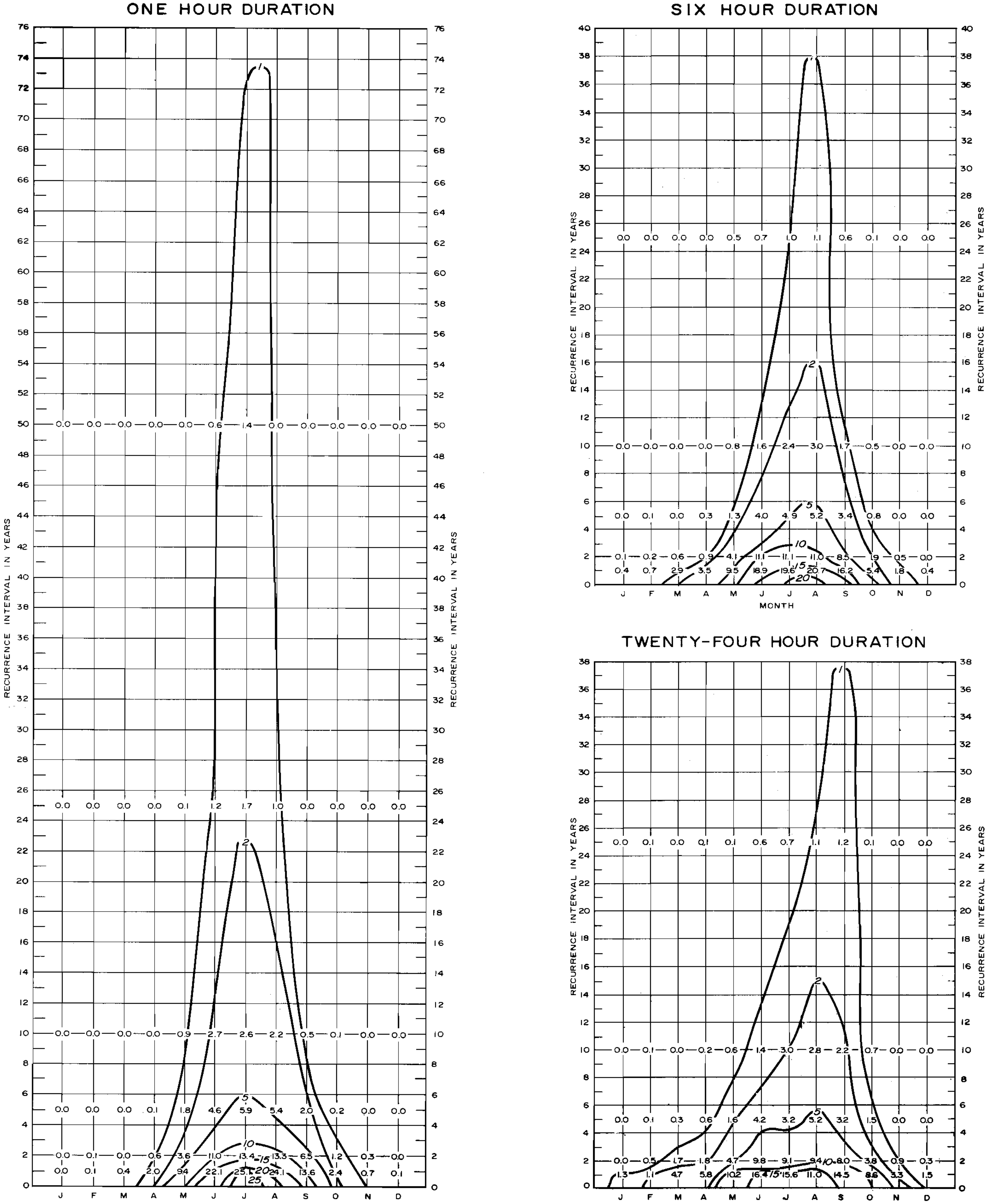
RAINFALL DEPTH-DURATION-AREA RELATIONSHIPS IN THE REGION AND THE MENOMONEE RIVER WATERSHED



Source: National Weather Service and SEWRPC.

Figure C-4

SEASONAL VARIATION OF RAINFALL EVENT DEPTH IN THE REGION AND THE MENOMONEE RIVER WATERSHED

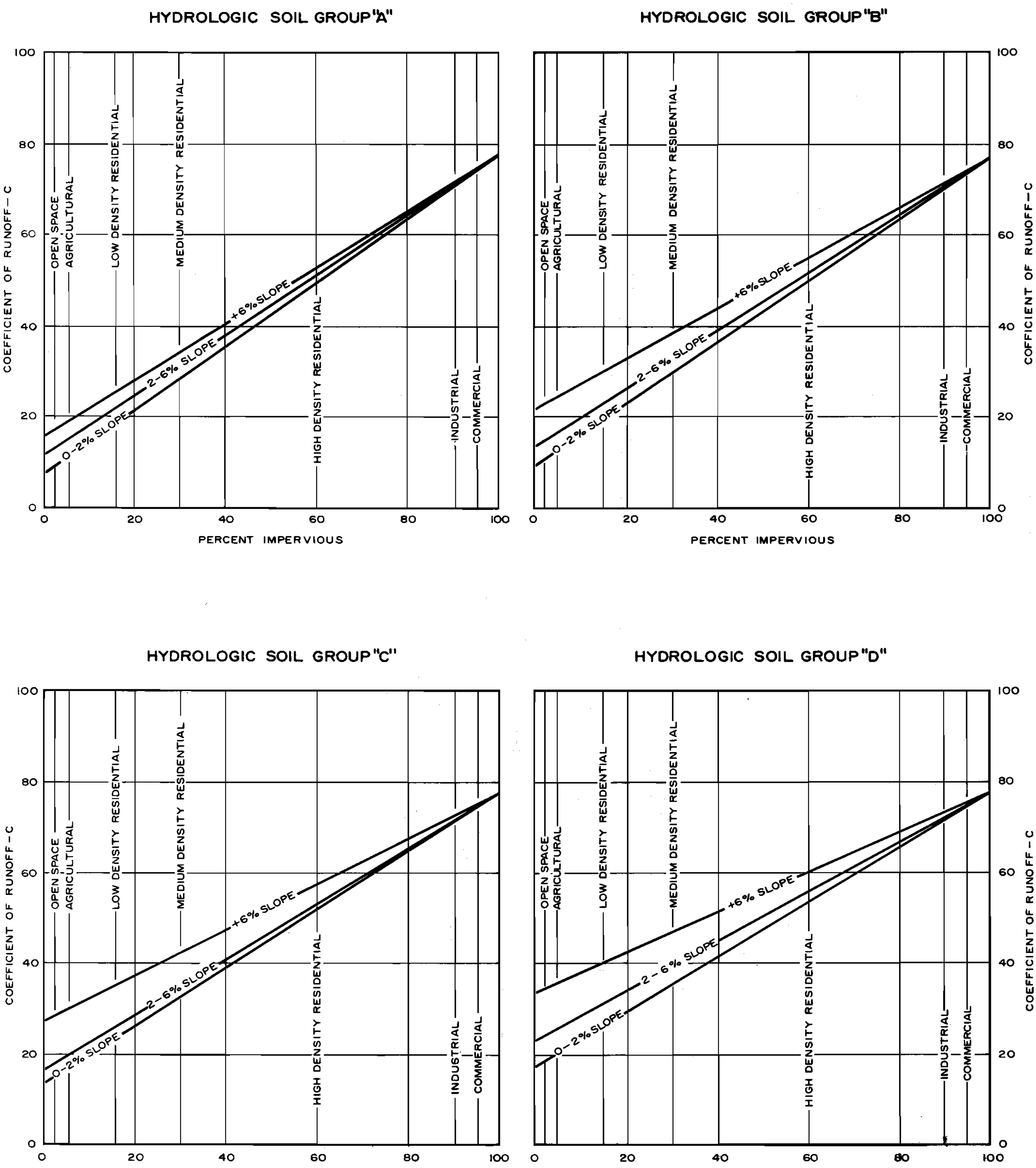


CURVE NUMBERS INDICATE THE PROBABILITY IN PERCENT OF OBTAINING A RAINFALL EVENT IN ANY MONTH OF A PARTICULAR YEAR WITH A DEPTH EQUAL TO OR GREATER THAN THE RAINFALL DEPTH CORRESPONDING TO A GIVEN RECURRENCE INTERVAL AS SHOWN IN FIGURE C-3.

Source: National Weather Service and SEWRPC.

Figure C-5

COEFFICIENT OF RUNOFF CURVES FOR HYDROLOGIC SOIL GROUPS



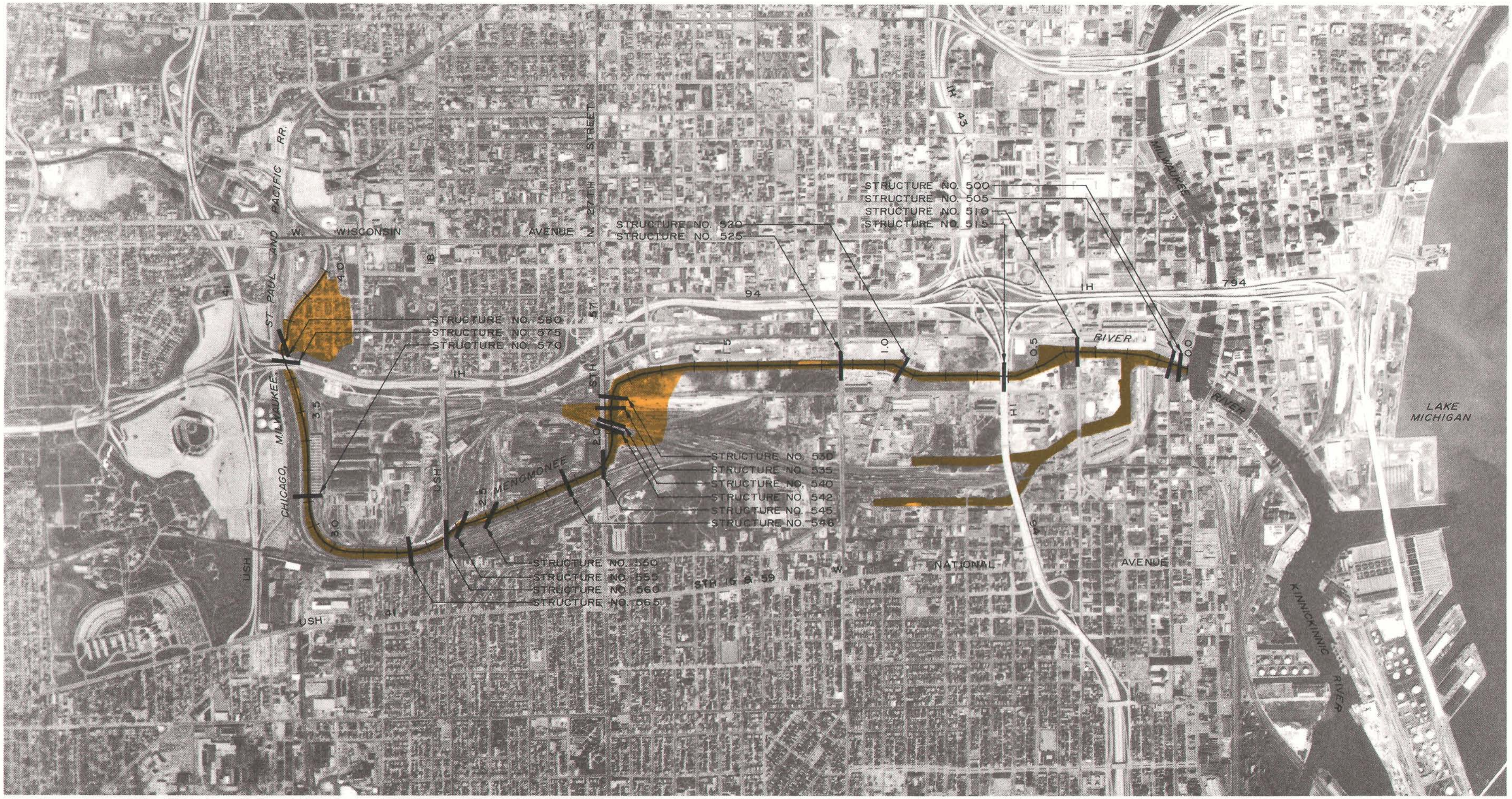
Source: SEWRPC.

Appendix D

FLOOD STAGE AND STREAMBED PROFILES AND AERIAL PHOTOGRAPHS SHOWING AREAS SUBJECT TO FLOODING

Map D-1

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE LOWER MENOMONEE RIVER (R. M. 0.00 to 4.00)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

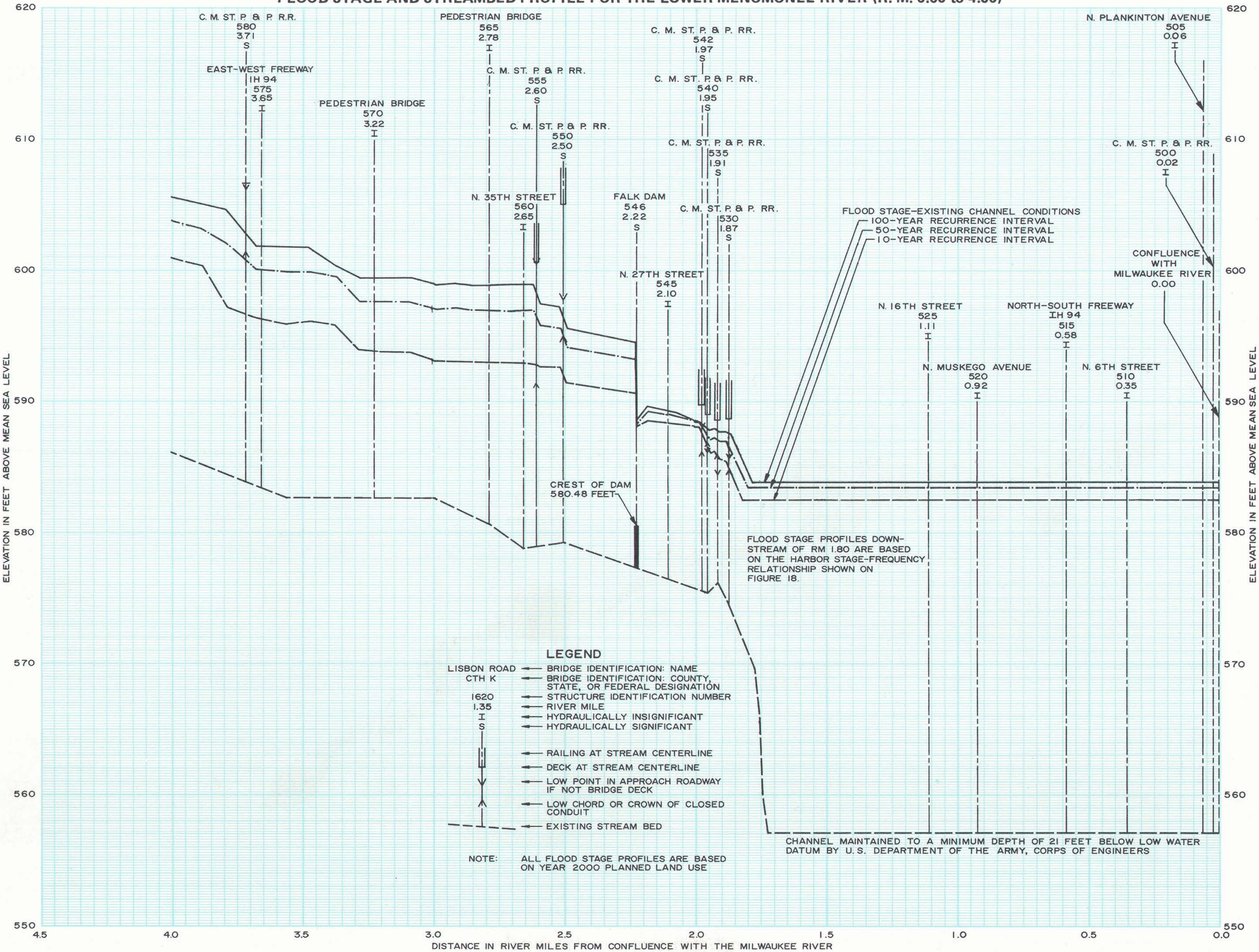
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-1

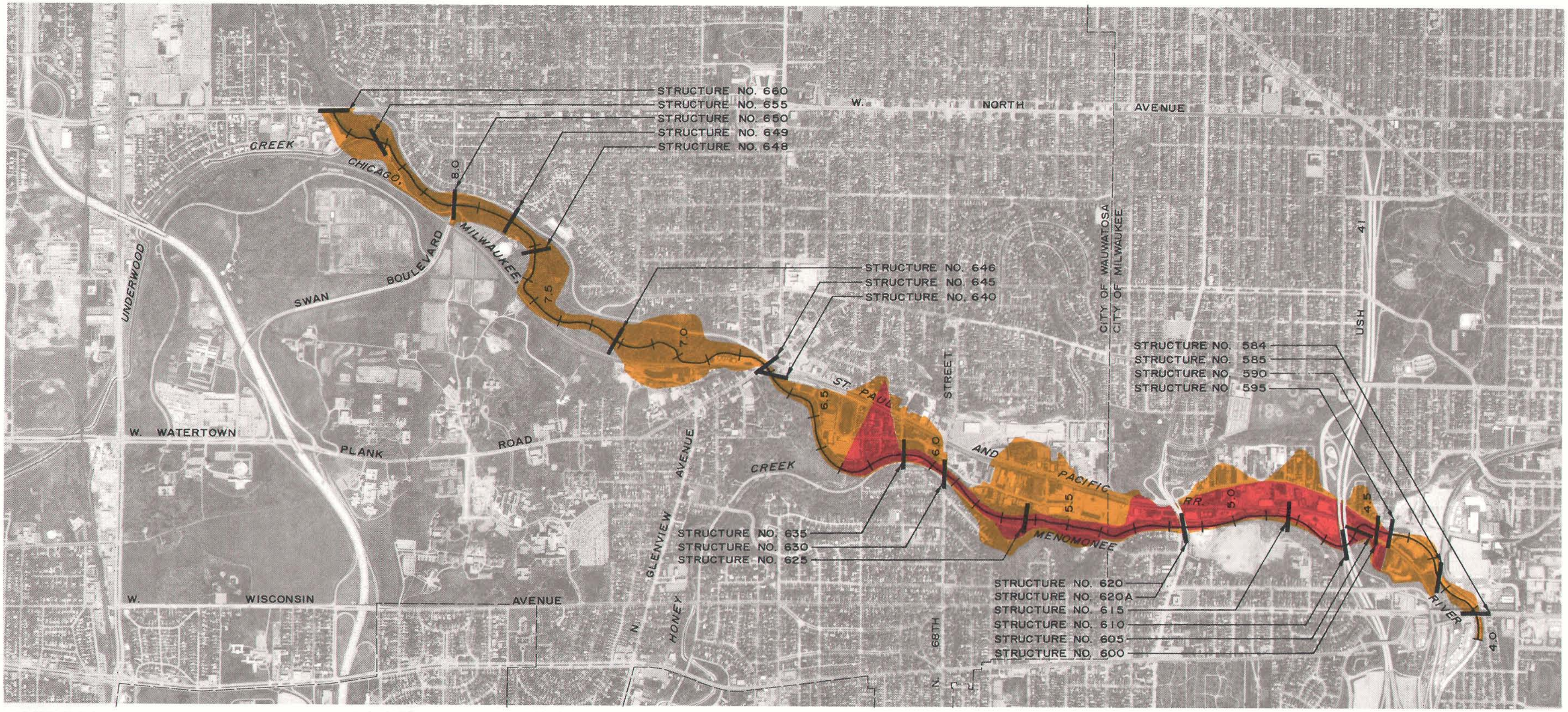
FLOOD STAGE AND STREAMBED PROFILE FOR THE LOWER MENOMONEE RIVER (R. M. 0.00 to 4.00)

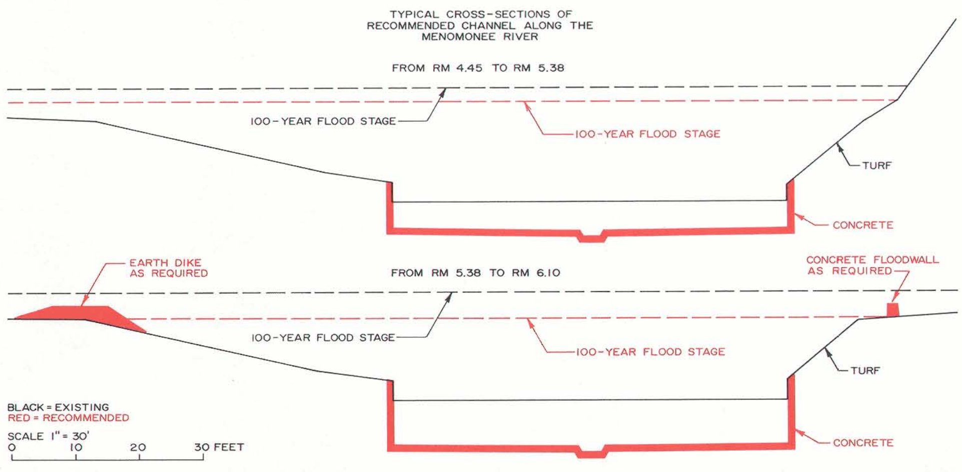


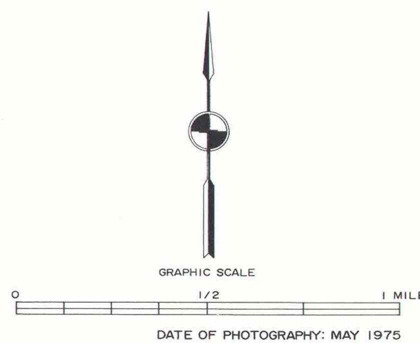
Source: SEWRPC.

Map D-2

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE LOWER MENOMONEE RIVER (R. M. 4.00 to 8.50)







LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

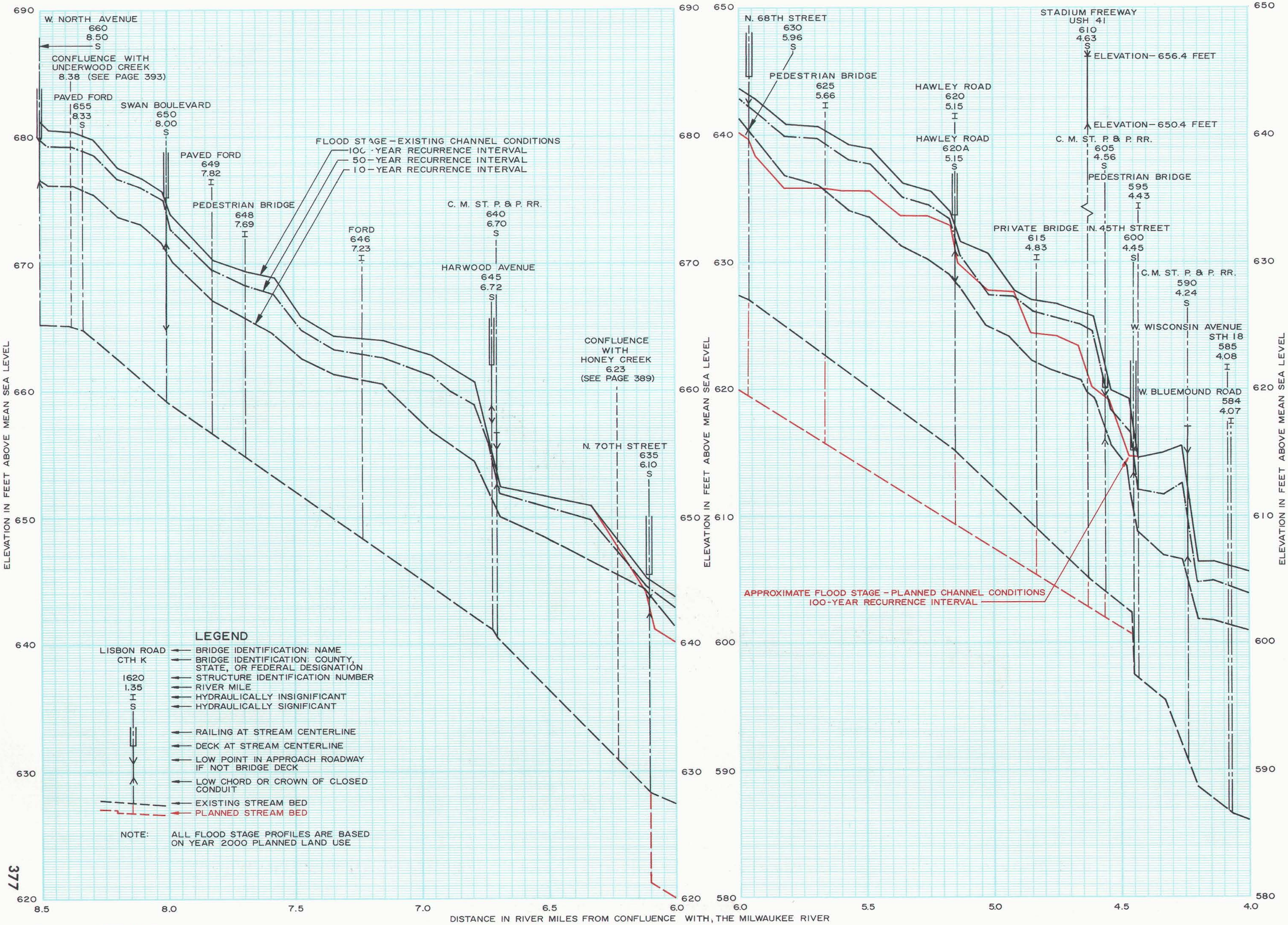
100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

APPROXIMATE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Source: SEWRPC.

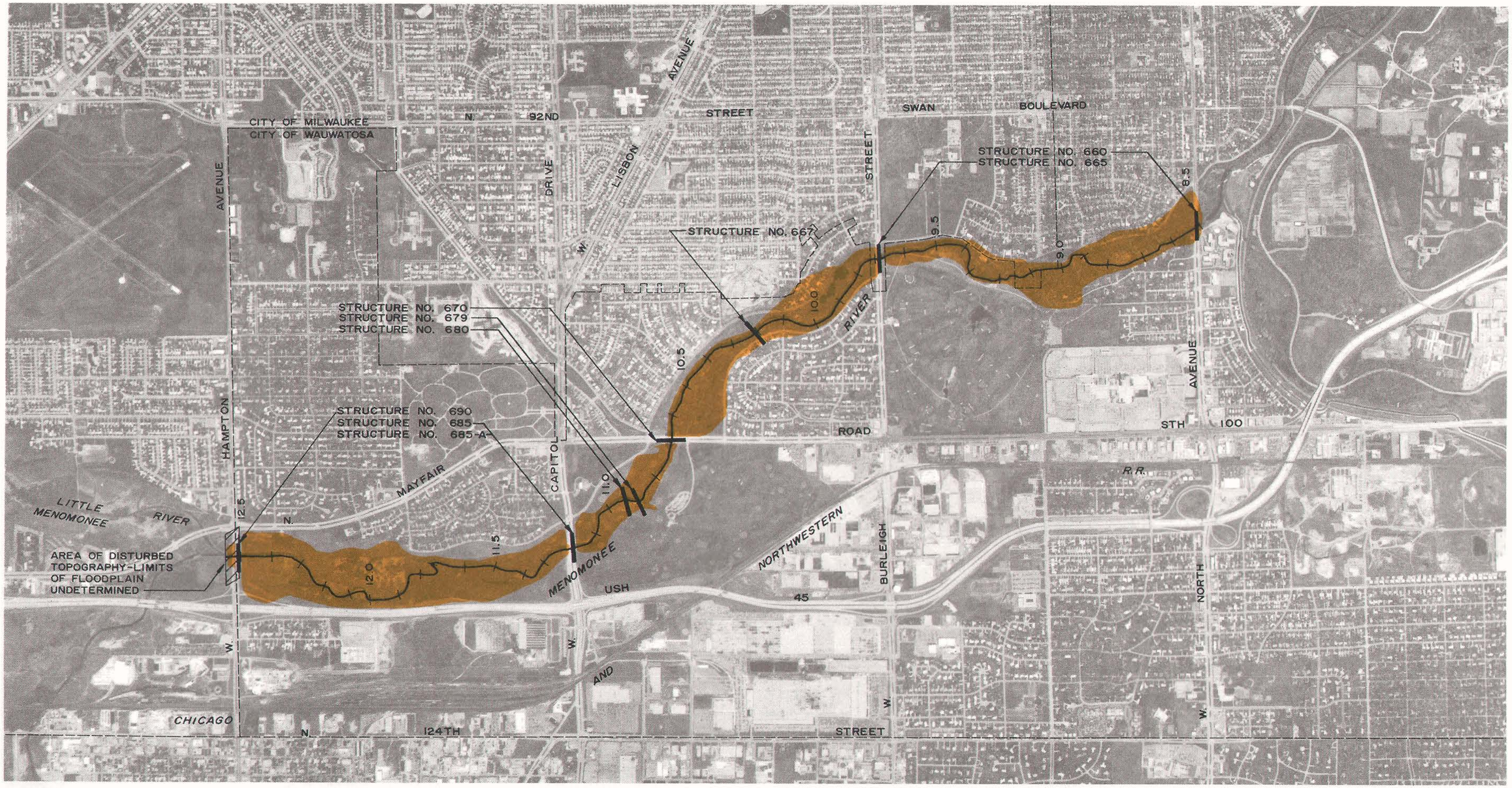
Figure D-2

FLOOD STAGE AND STREAMBED PROFILE FOR THE LOWER MENOMONEE RIVER (R. M. 4.00 to 8.50)



Map D-3

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE LOWER MENOMONEE RIVER (R. M. 8.50 to 12.57)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

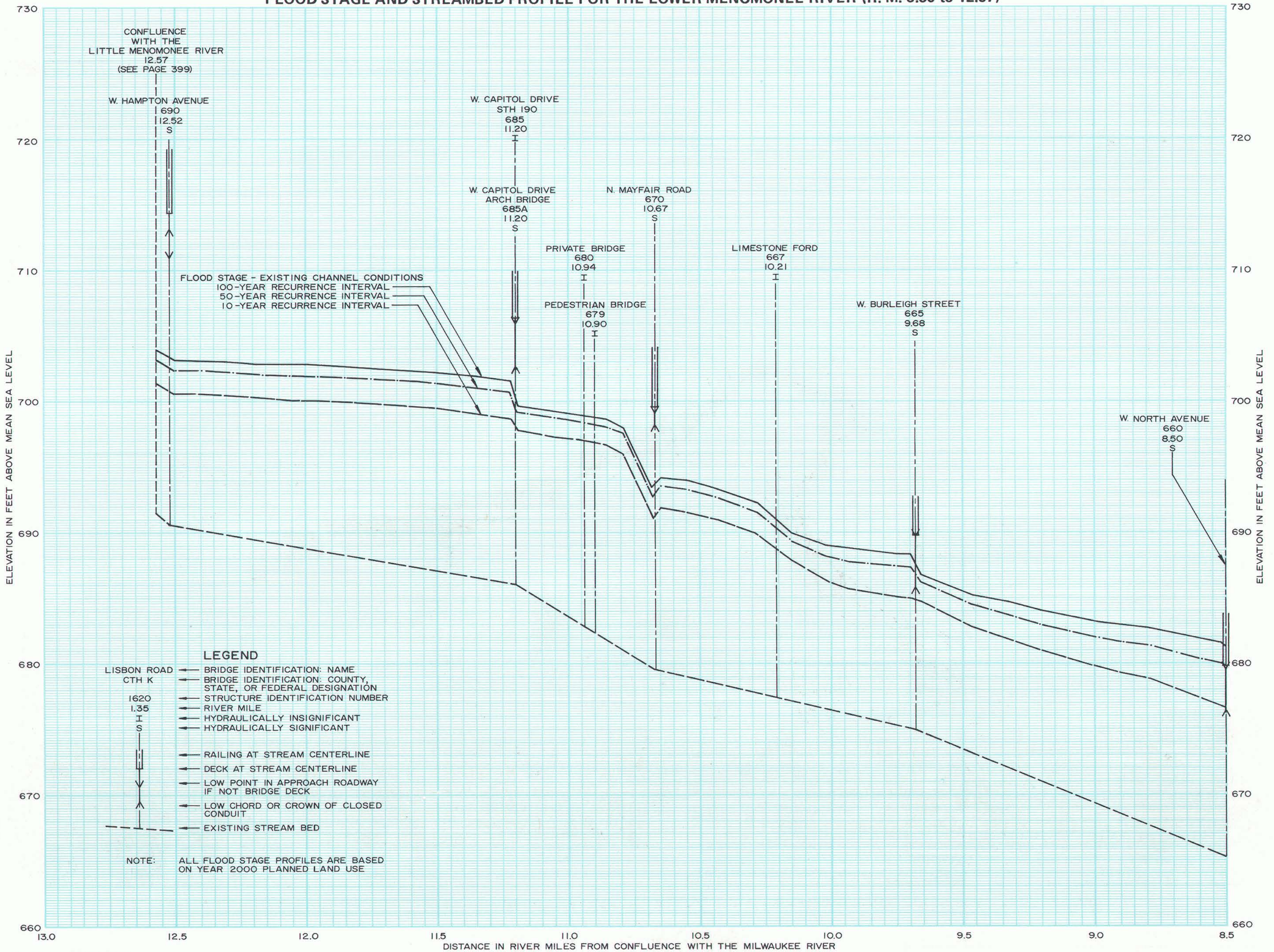
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-3

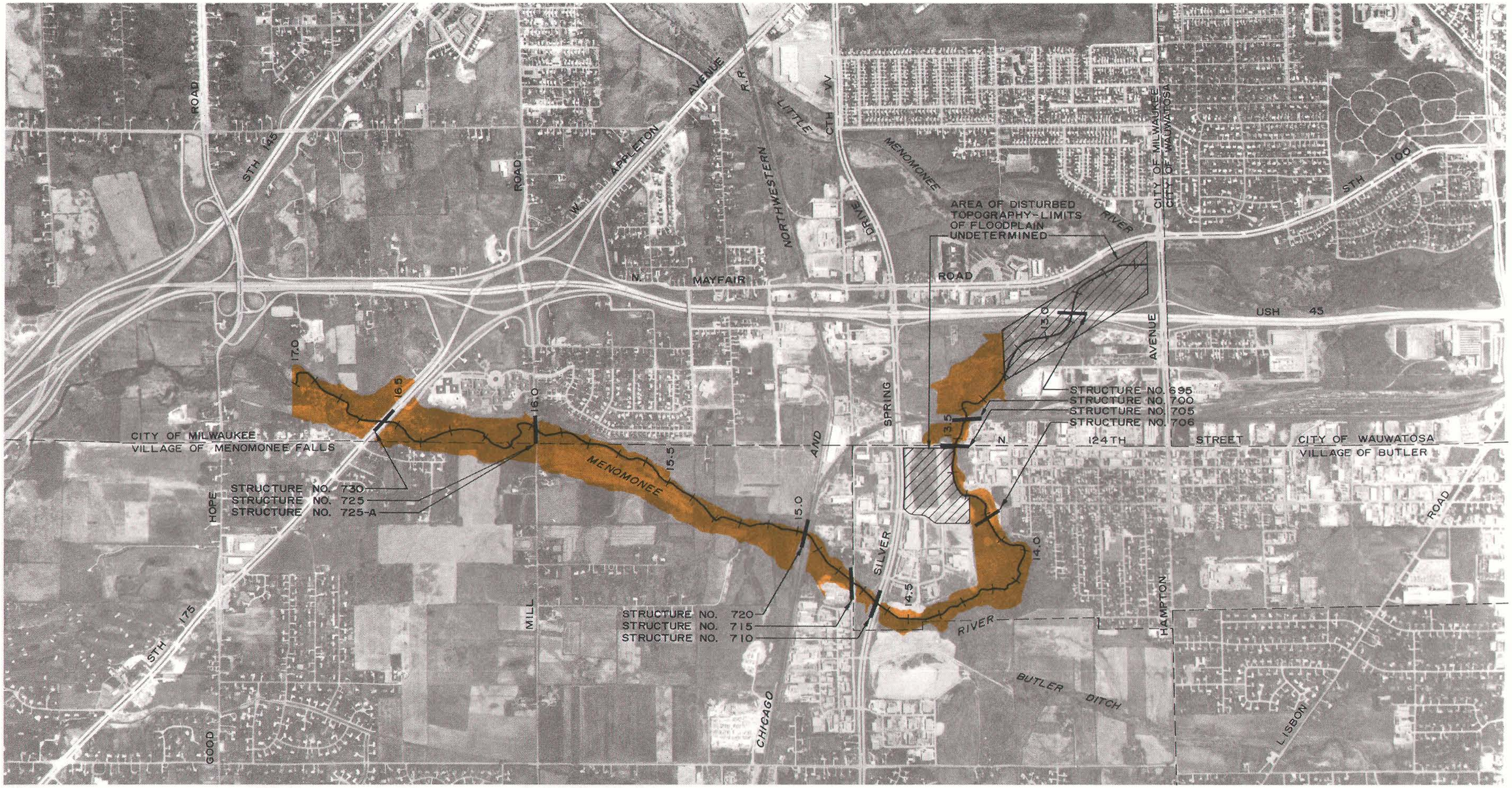
FLOOD STAGE AND STREAMBED PROFILE FOR THE LOWER MENOMONEE RIVER (R. M. 8.50 to 12.57)



Source: SEWRPC.

Map D-4

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE UPPER MENOMONEE RIVER (R. M. 12.57 to 17.00)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

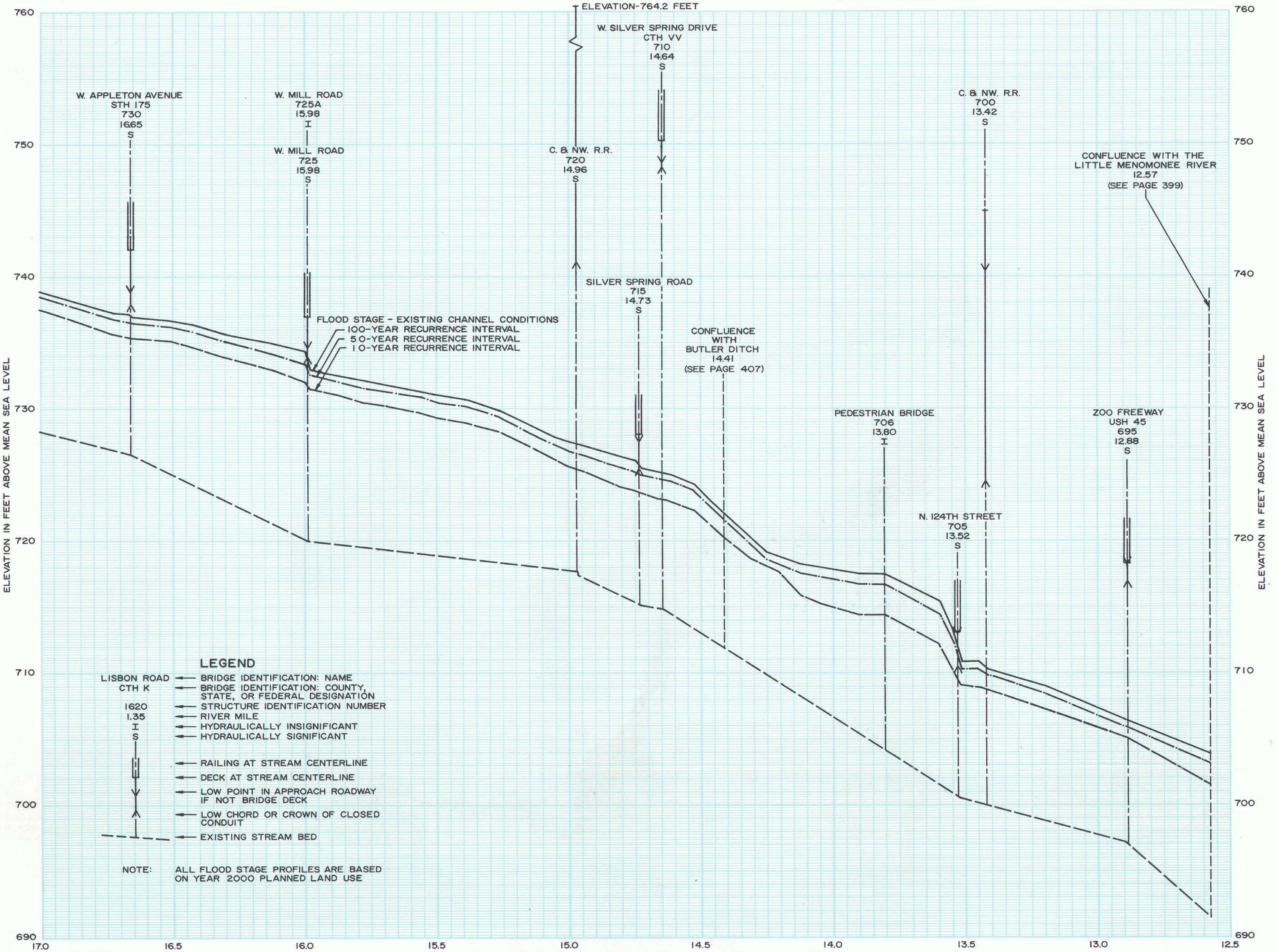
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-4

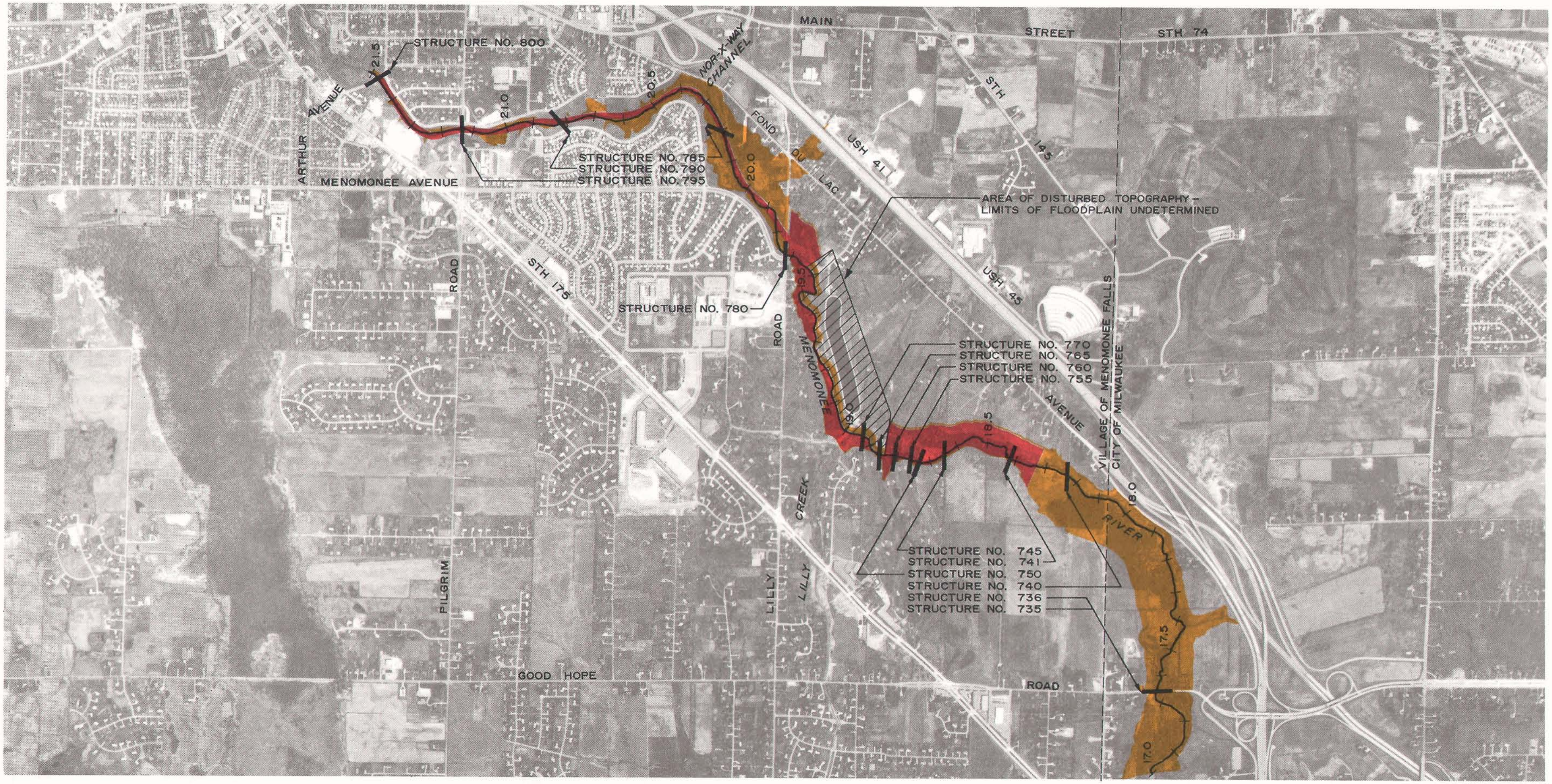
FLOOD STAGE AND STREAMBED PROFILE FOR THE UPPER MENOMONEE RIVER (R. M. 12.57 to 17.00)



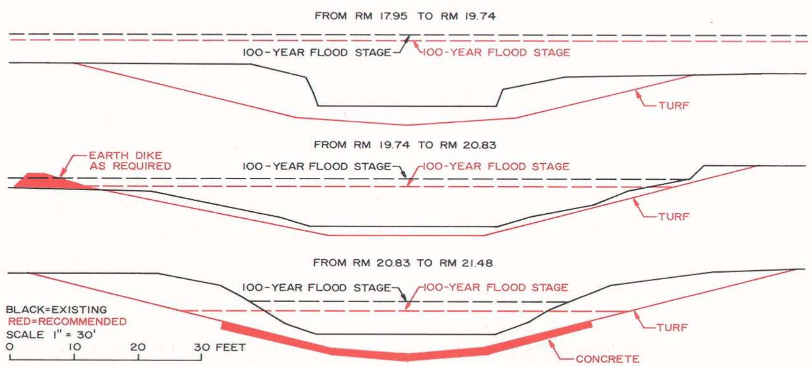
Source: SEWRPC.

Map D-5

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE UPPER MENOMONEE RIVER (R. M. 17.00 to 21.50)



TYPICAL CROSS-SECTIONS OF RECOMMENDED CHANNEL ALONG THE MENOMONEE RIVER

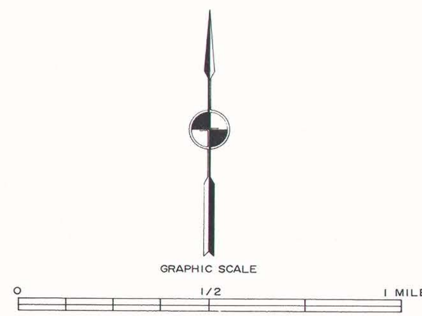


LEGEND


APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

APPROXIMATE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

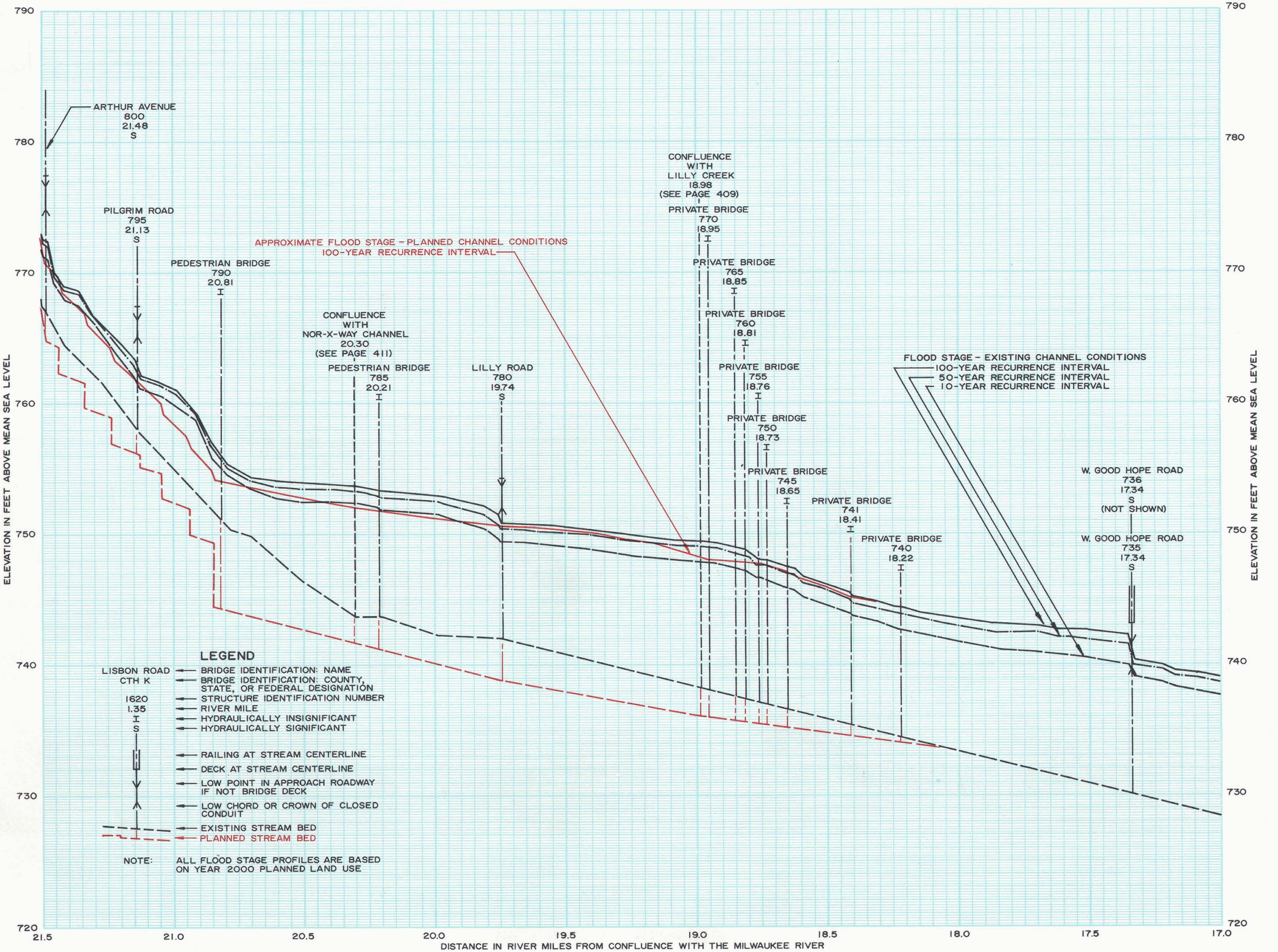


DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

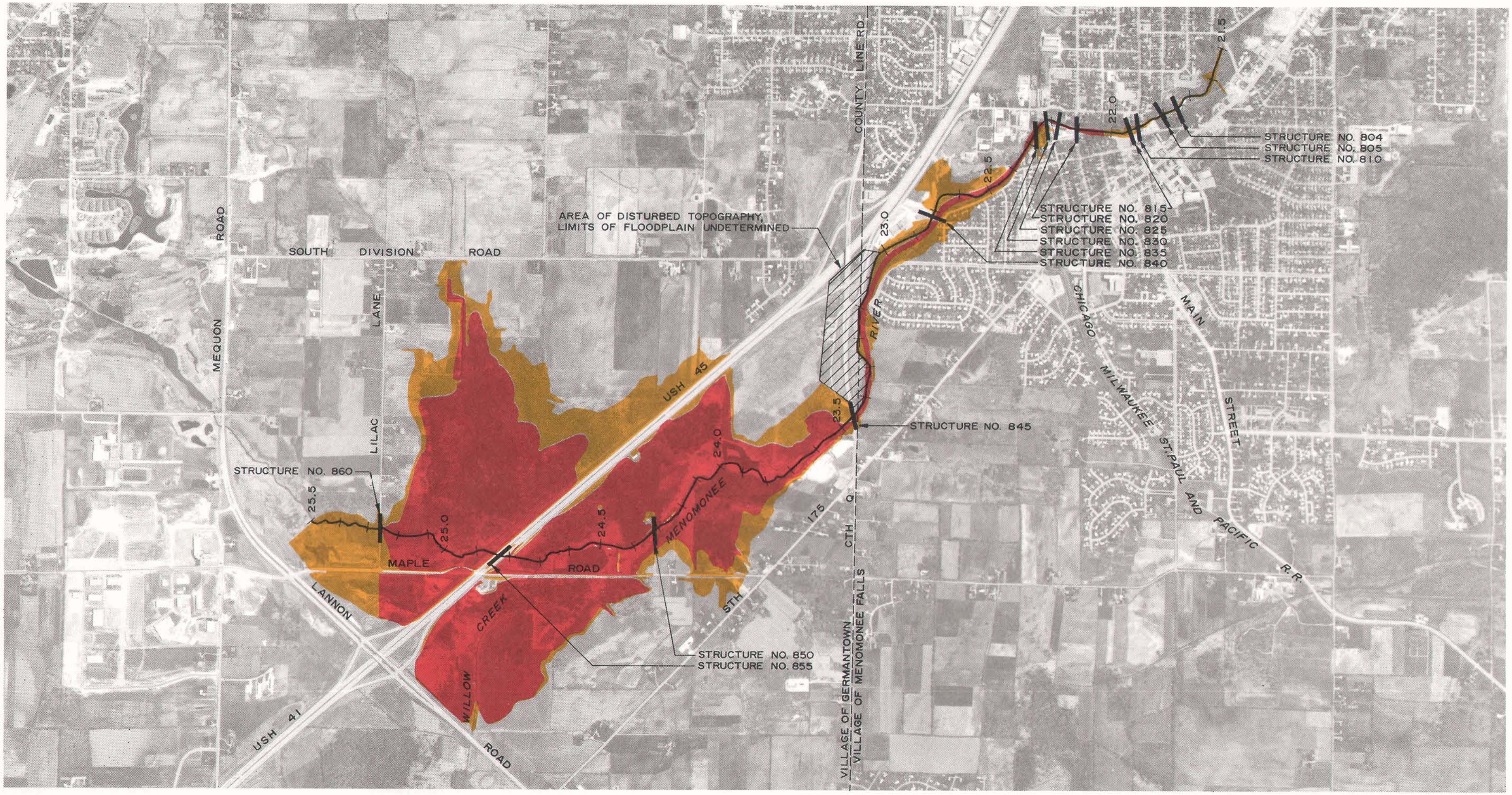
Figure D-5

FLOOD STAGE AND STREAMBED PROFILE FOR THE UPPER MENOMONEE RIVER (R. M. 17.00 to 21.50)



Map D-6

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE UPPER MENOMONEE RIVER (R. M. 21.50 to 25.50)



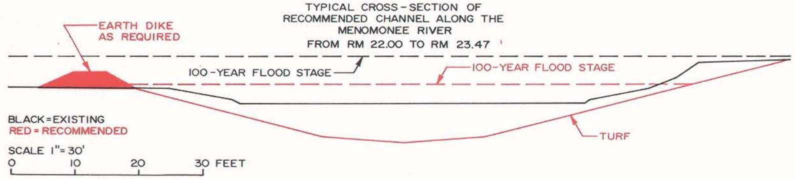
LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

APPROXIMATE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

TYPICAL CROSS-SECTION OF RECOMMENDED CHANNEL ALONG THE MENOMONEE RIVER FROM RM 22.00 TO RM 23.47



GRAPHIC SCALE

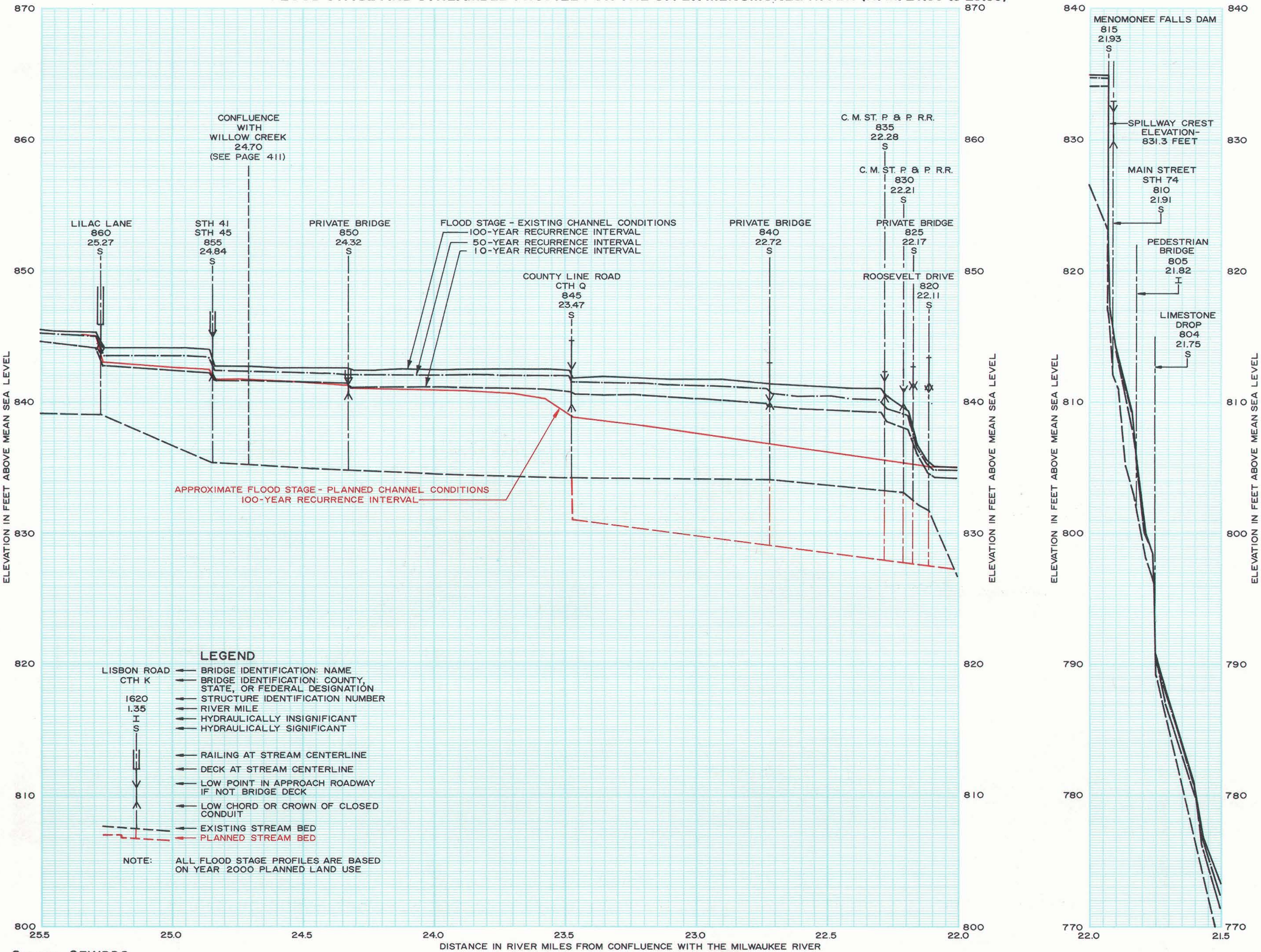
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-6

FLOOD STAGE AND STREAMBED PROFILE FOR THE UPPER MENOMONEE RIVER (R. M. 21.50 to 25.50)



Source: SEWRPC.

Map D-7

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE UPPER MENOMONEE RIVER (R. M. 25.50 to 29.41)

LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

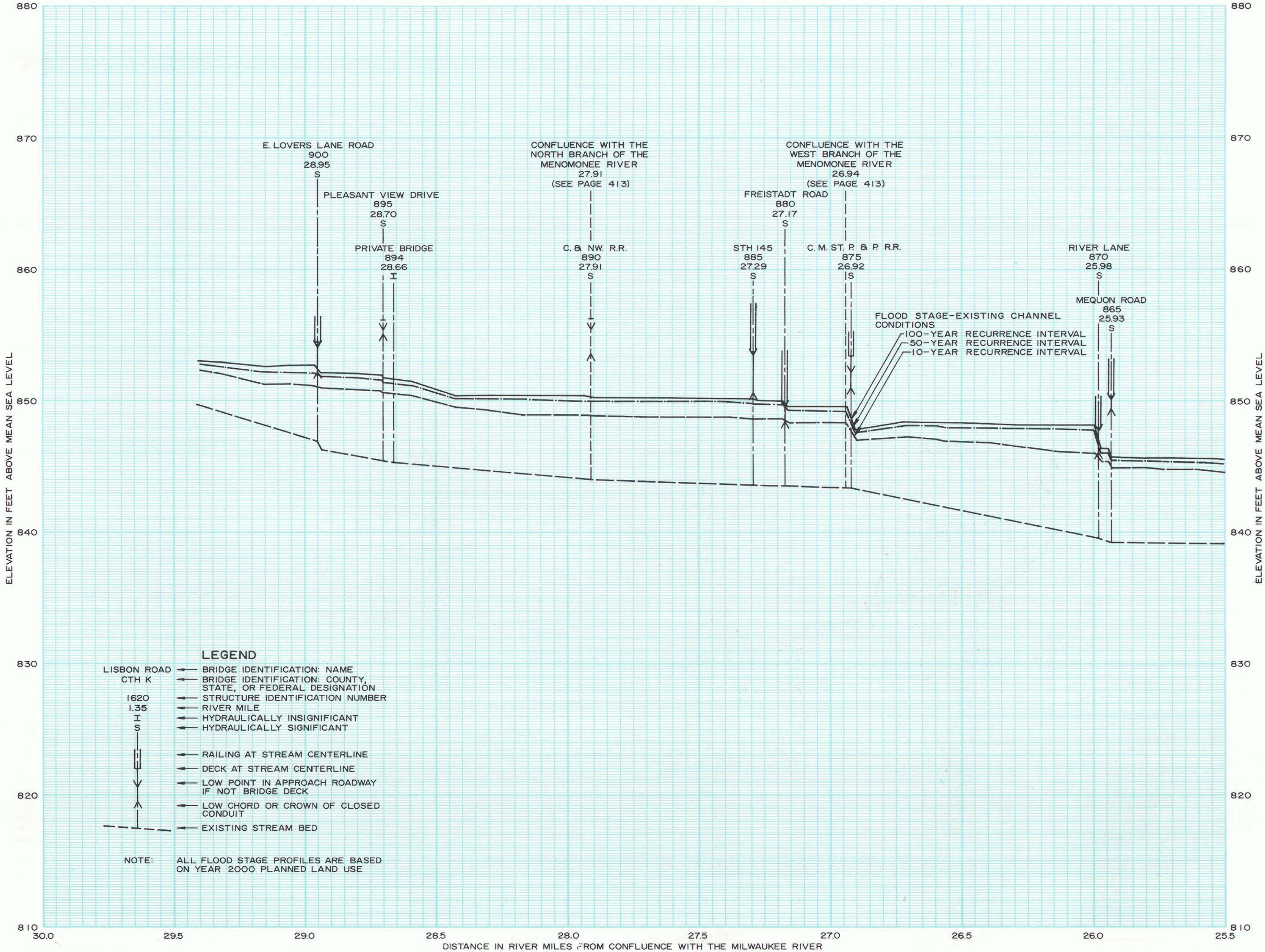
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-7

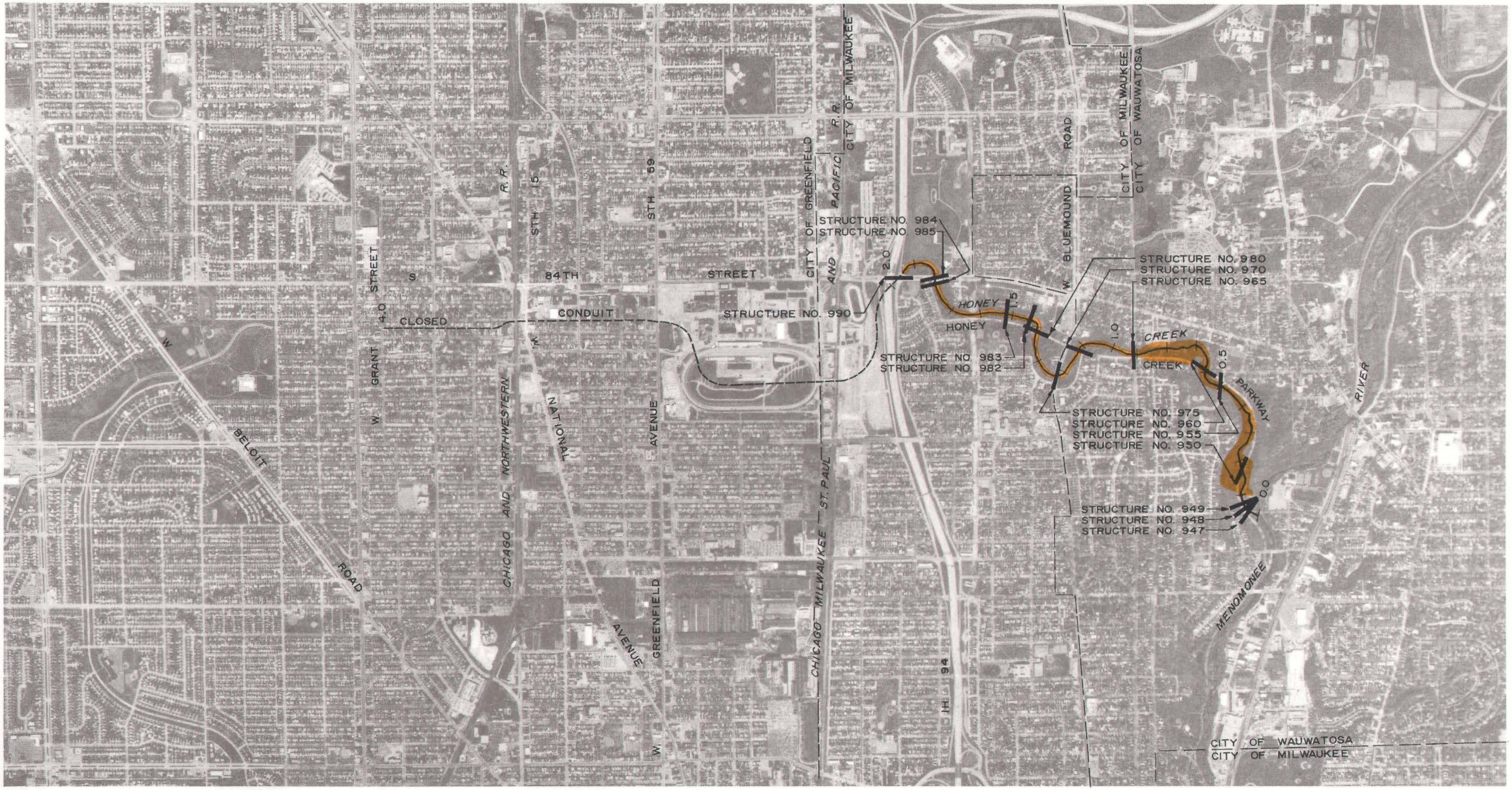
FLOOD STAGE AND STREAMBED PROFILE FOR THE UPPER MENOMONEE RIVER (R. M. 25.50 to 29.41)



Source: SEWRPC.

Map D-8

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG HONEY CREEK (R. M. 0.00 to 4.00)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

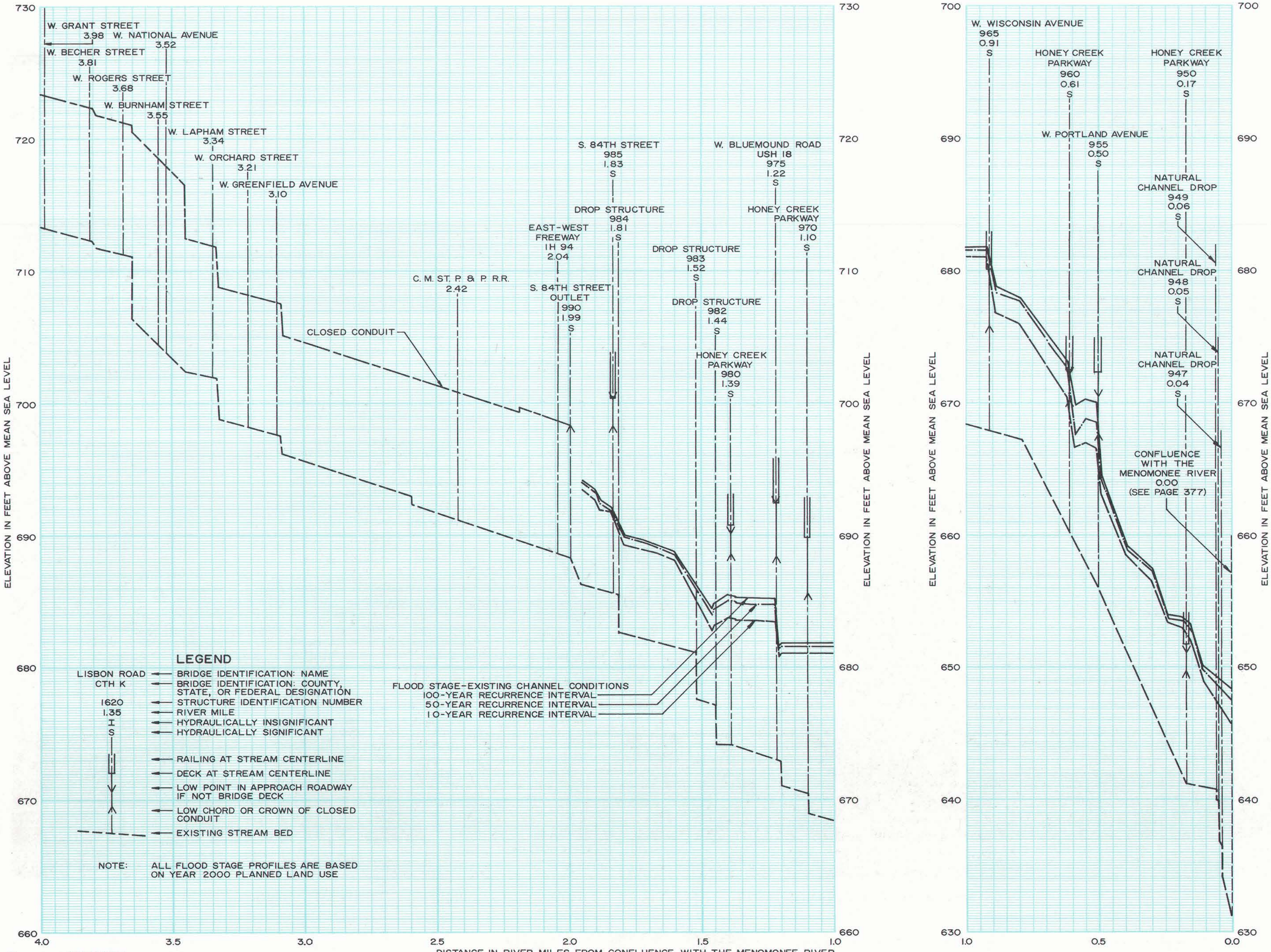
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-8

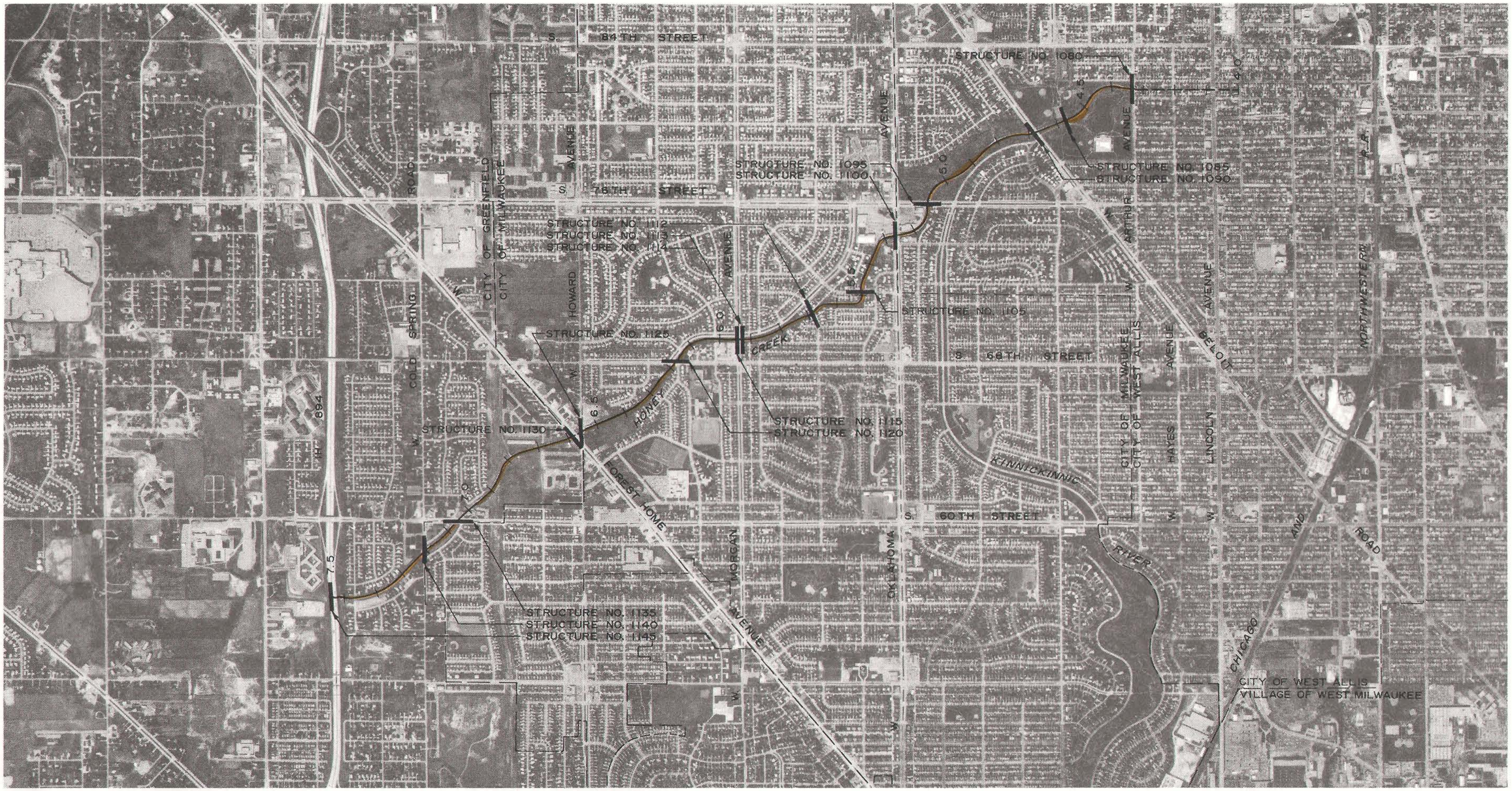
FLOOD STAGE AND STREAMBED PROFILE FOR HONEY CREEK (R. M. 0.00 to 4.00)



Source: SEWRPC.

Map D-9

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG HONEY CREEK (R. M. 4.00 to 7.55)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

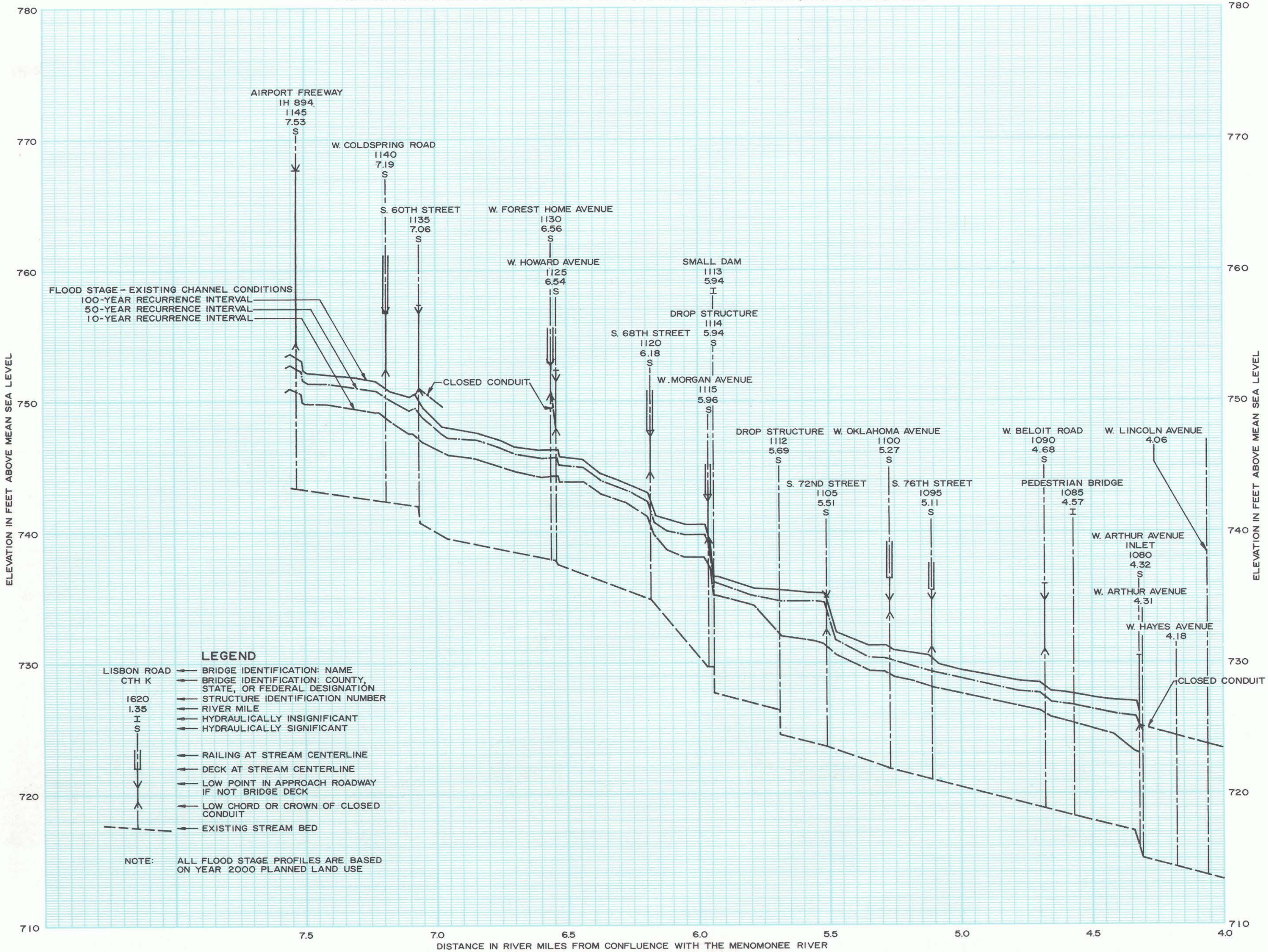
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-9

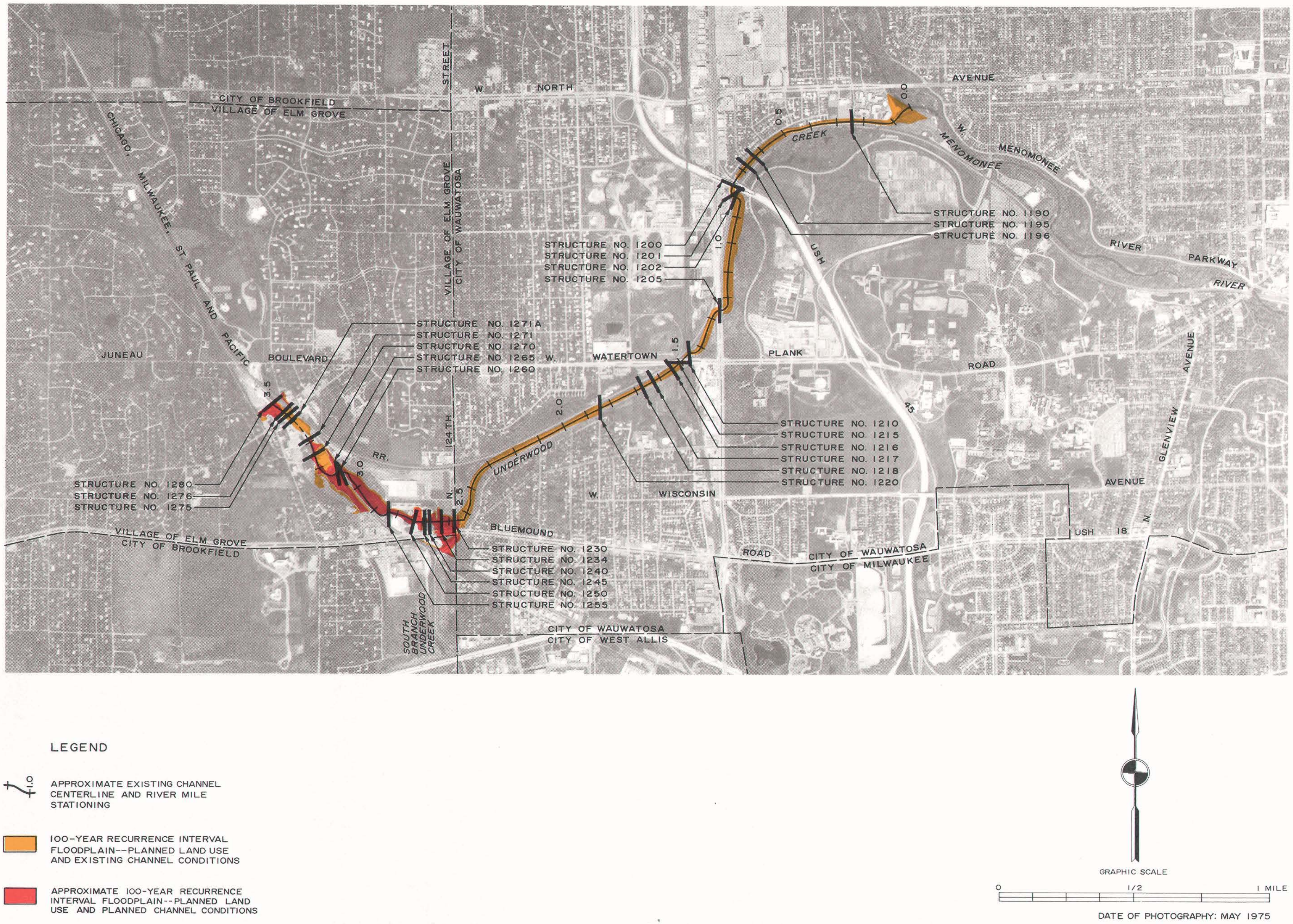
FLOOD STAGE AND STREAMBED PROFILE FOR HONEY CREEK (R. M. 4.00 to 7.55)



Source: SEWRPC.

Map D-10

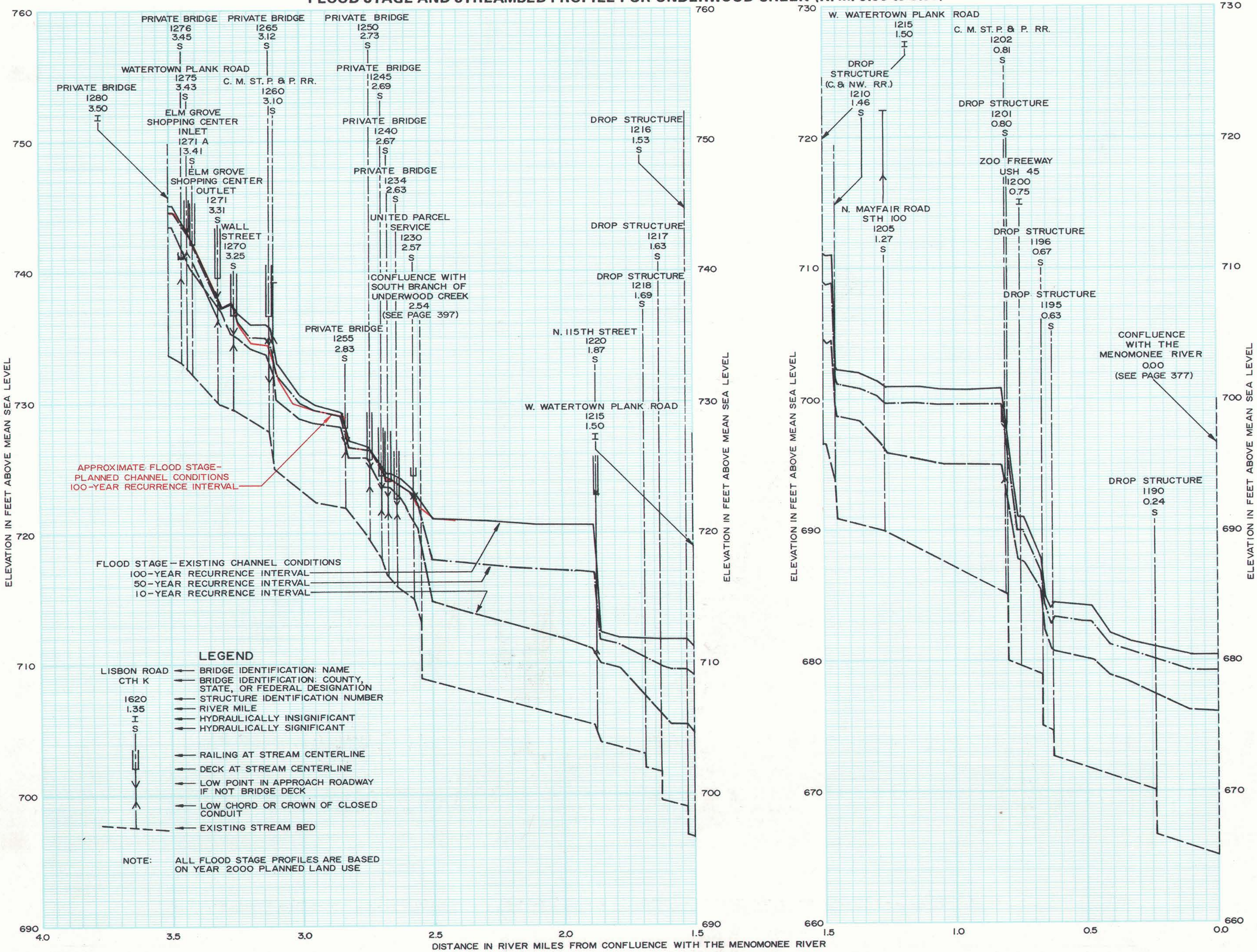
AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG UNDERWOOD CREEK (R. M. 0.00 to 3.50)



Source: SEWRPC.

Figure D-10

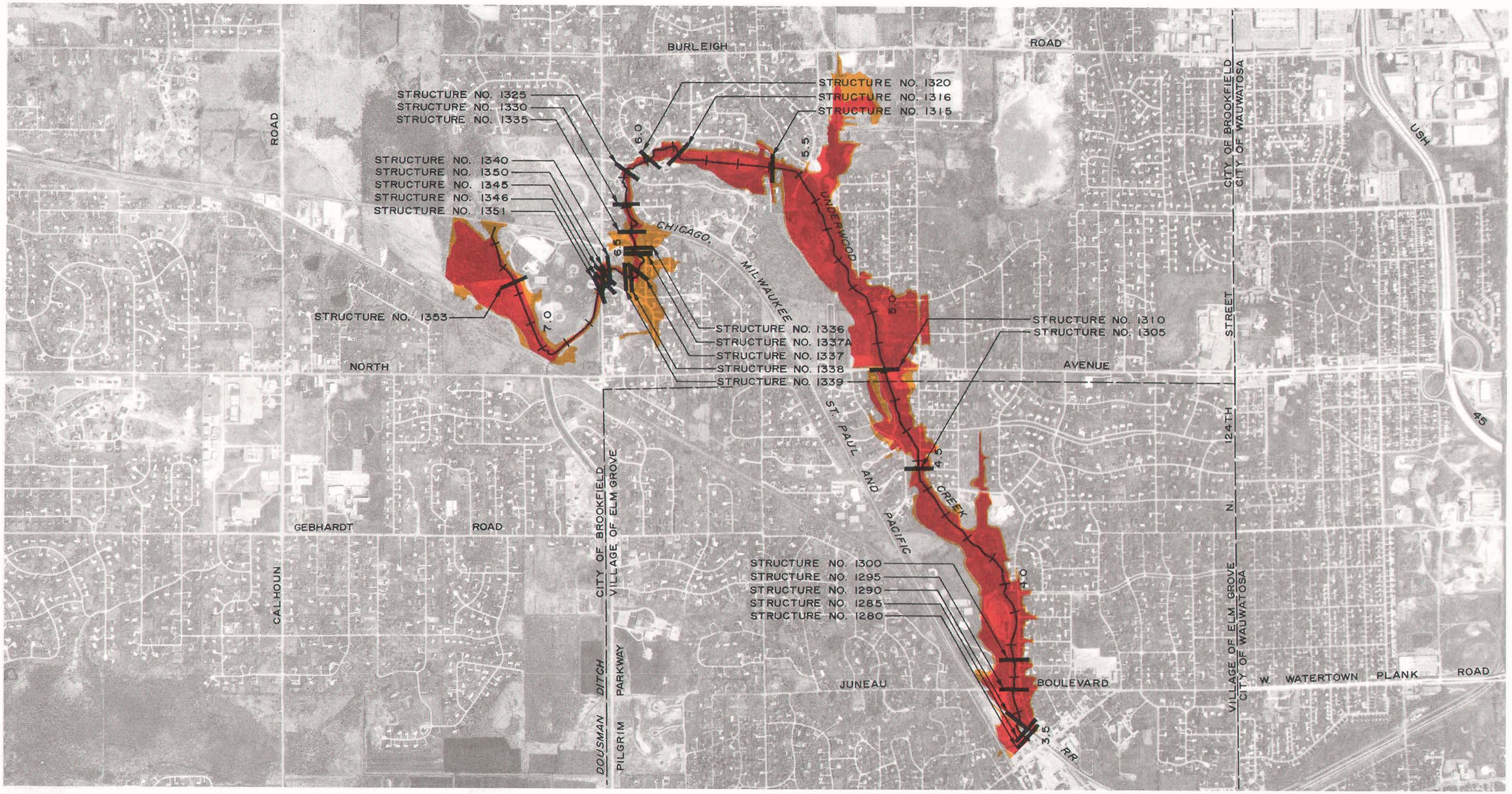
FLOOD STAGE AND STREAMBED PROFILE FOR UNDERWOOD CREEK (R. M. 0.00 to 3.50)



Source: SEWRPC.

Map D-11

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG UNDERWOOD CREEK (R. M. 3.50 to 7.47)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

APPROXIMATE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

GRAPHIC SCALE

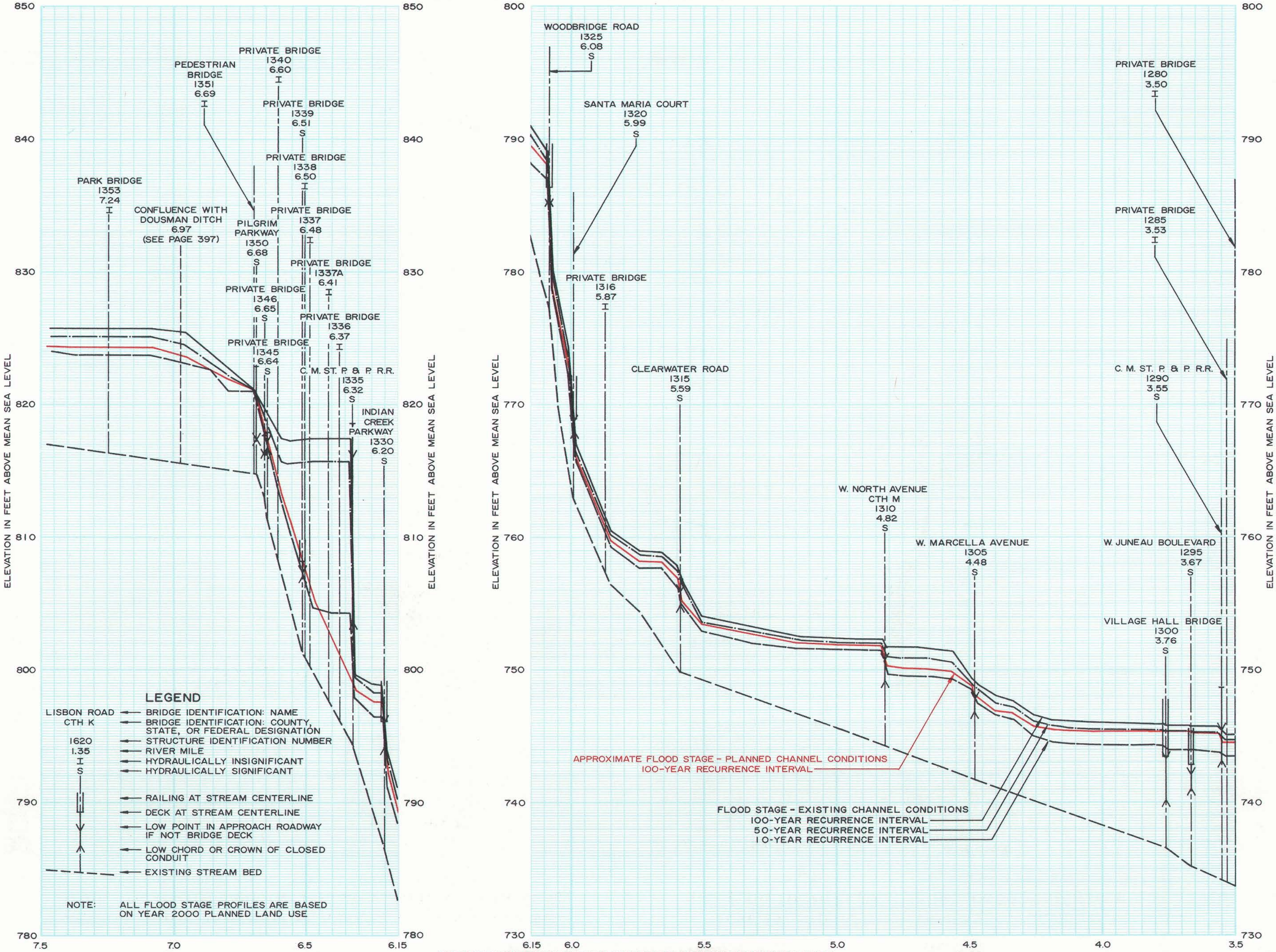
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-11

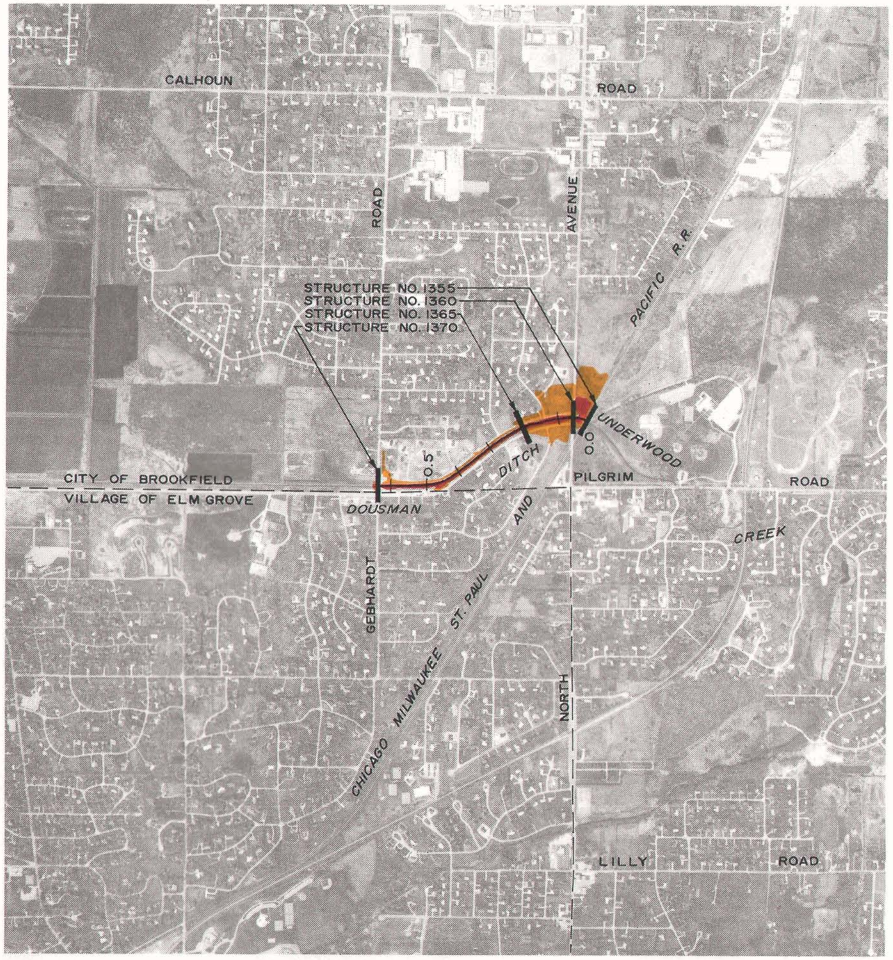
FLOOD STAGE AND STREAMBED PROFILE FOR UNDERWOOD CREEK (R. M. 3.50 to 7.47)



Source: SEWRPC.

Map D-13

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE SOUTH BRANCH OF DOUSMAN DITCH (R. M. 0.00 to 0.64)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

APPROXIMATE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

GRAPHIC SCALE

0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Map D-12

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE SOUTH BRANCH OF UNDERWOOD CREEK (R. M. 0.00 to 1.08)

LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-13

FLOOD STAGE AND STREAMBED PROFILE FOR DOUSMAN DITCH (R. M. 0.00 to 0.64)

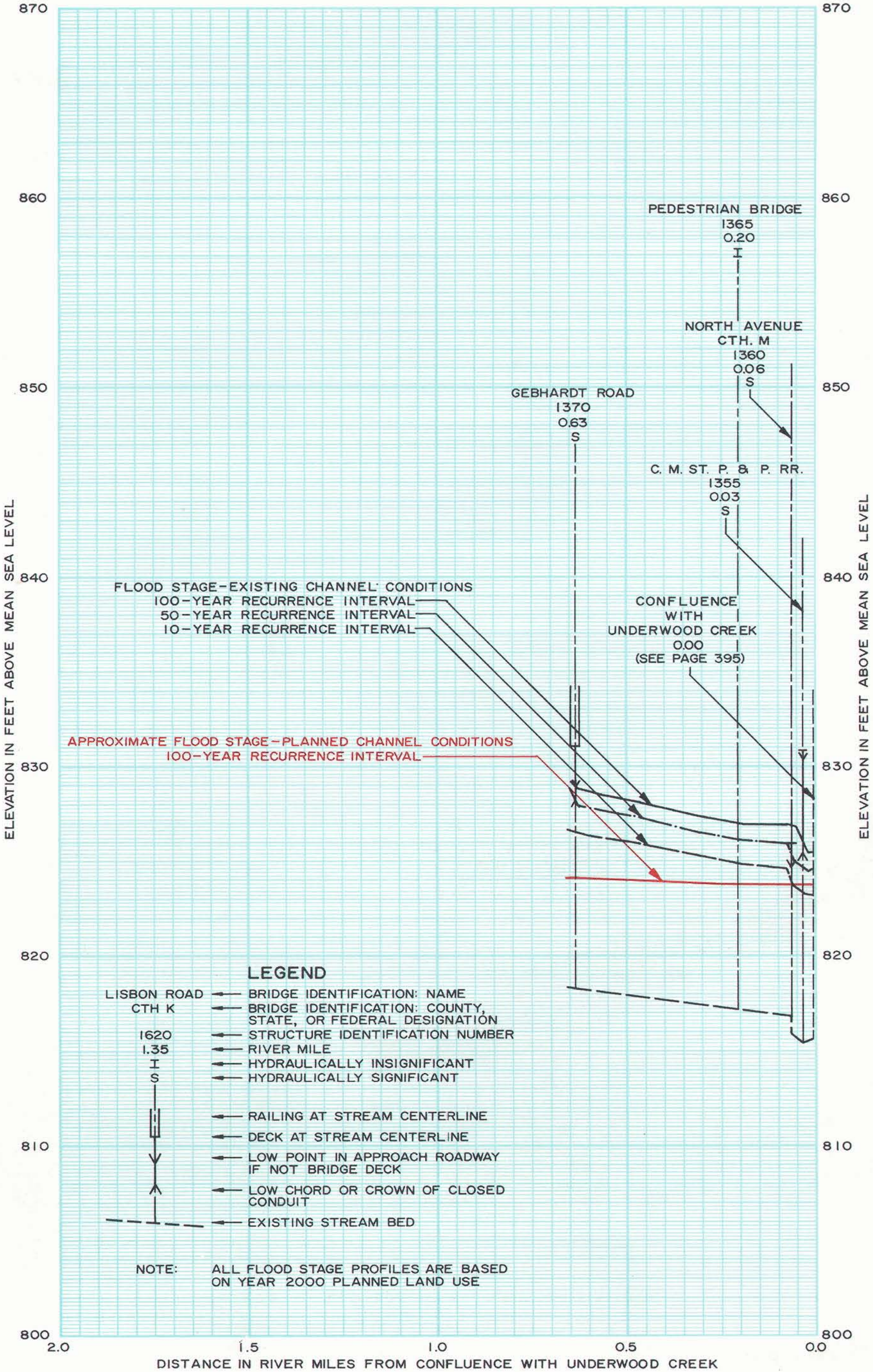
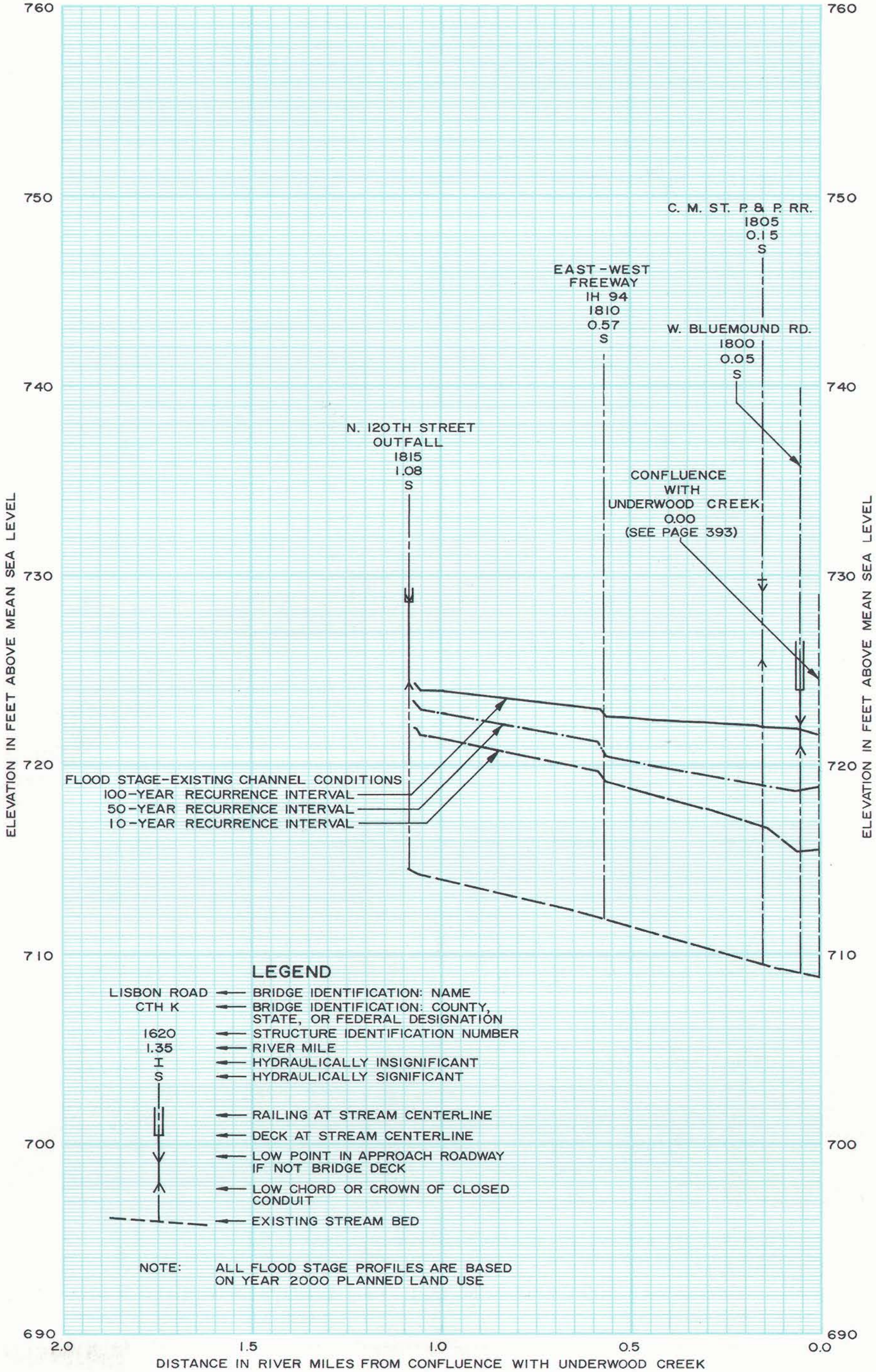


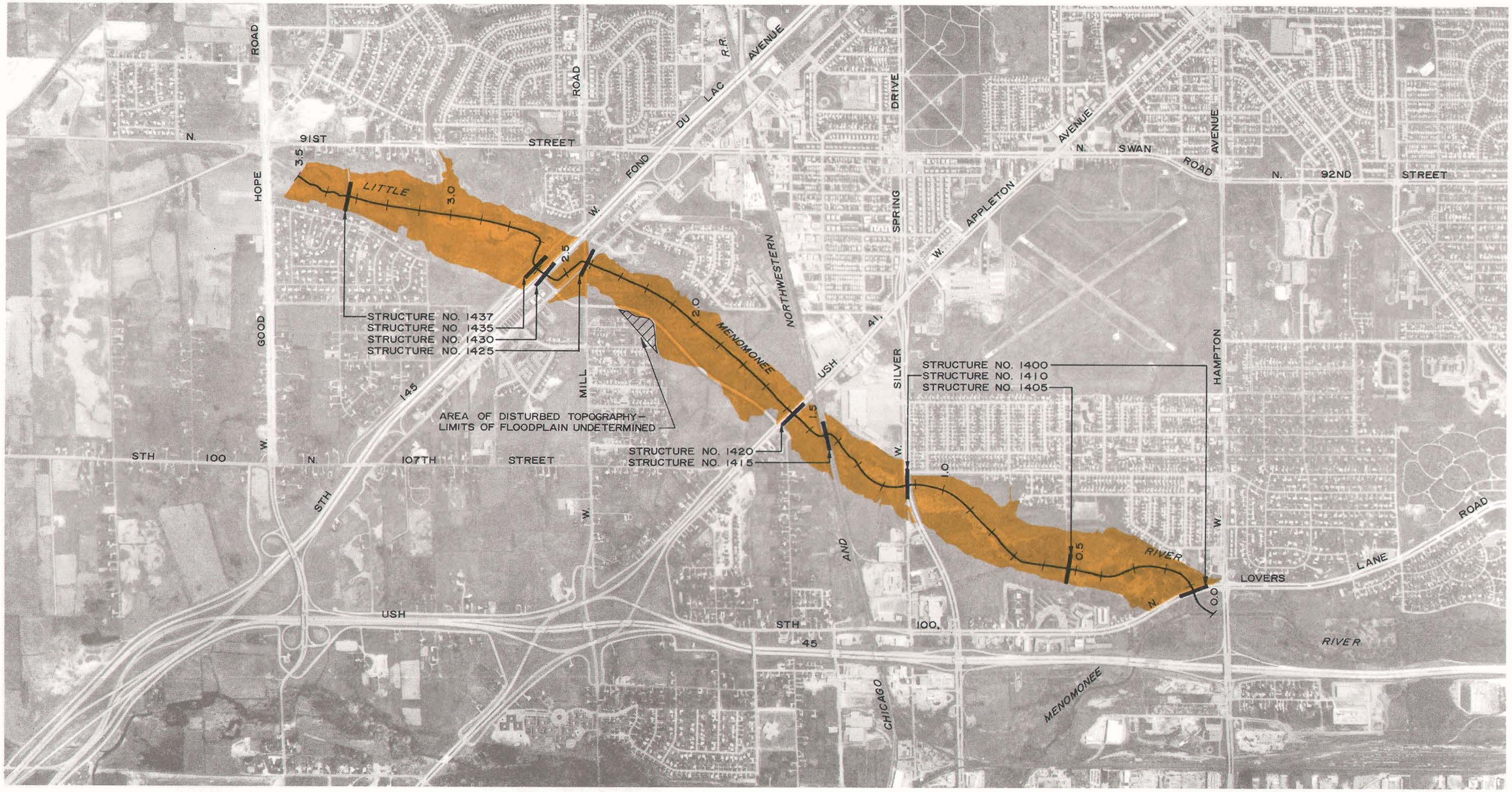
Figure D-12

FLOOD STAGE AND STREAMBED PROFILE FOR THE SOUTH BRANCH OF UNDERWOOD CREEK (R. M. 0.00 to 1.08)



Map D-14

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE LITTLE MENOMONEE RIVER (R. M. 0.00 to 3.50)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

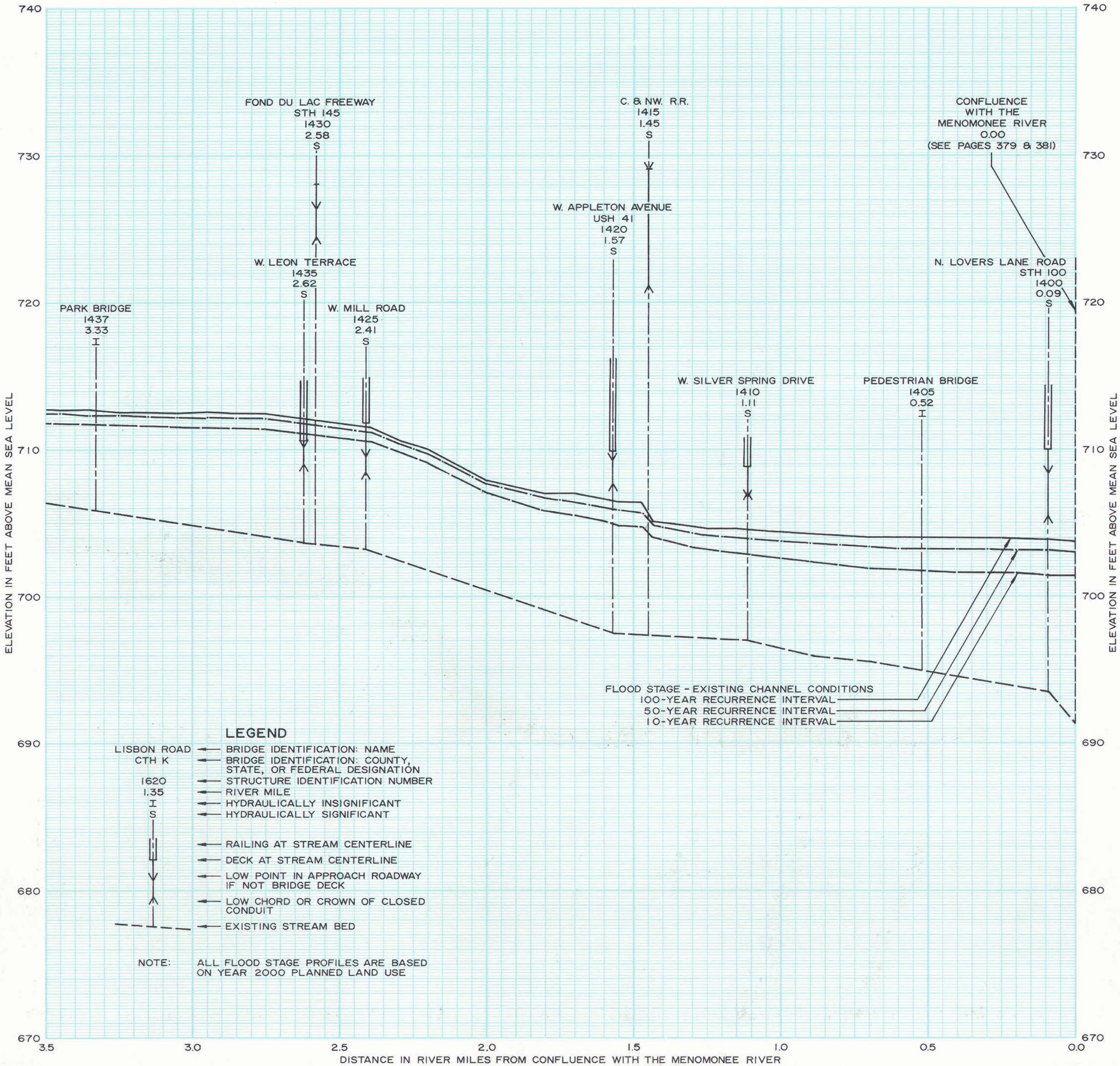
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-14

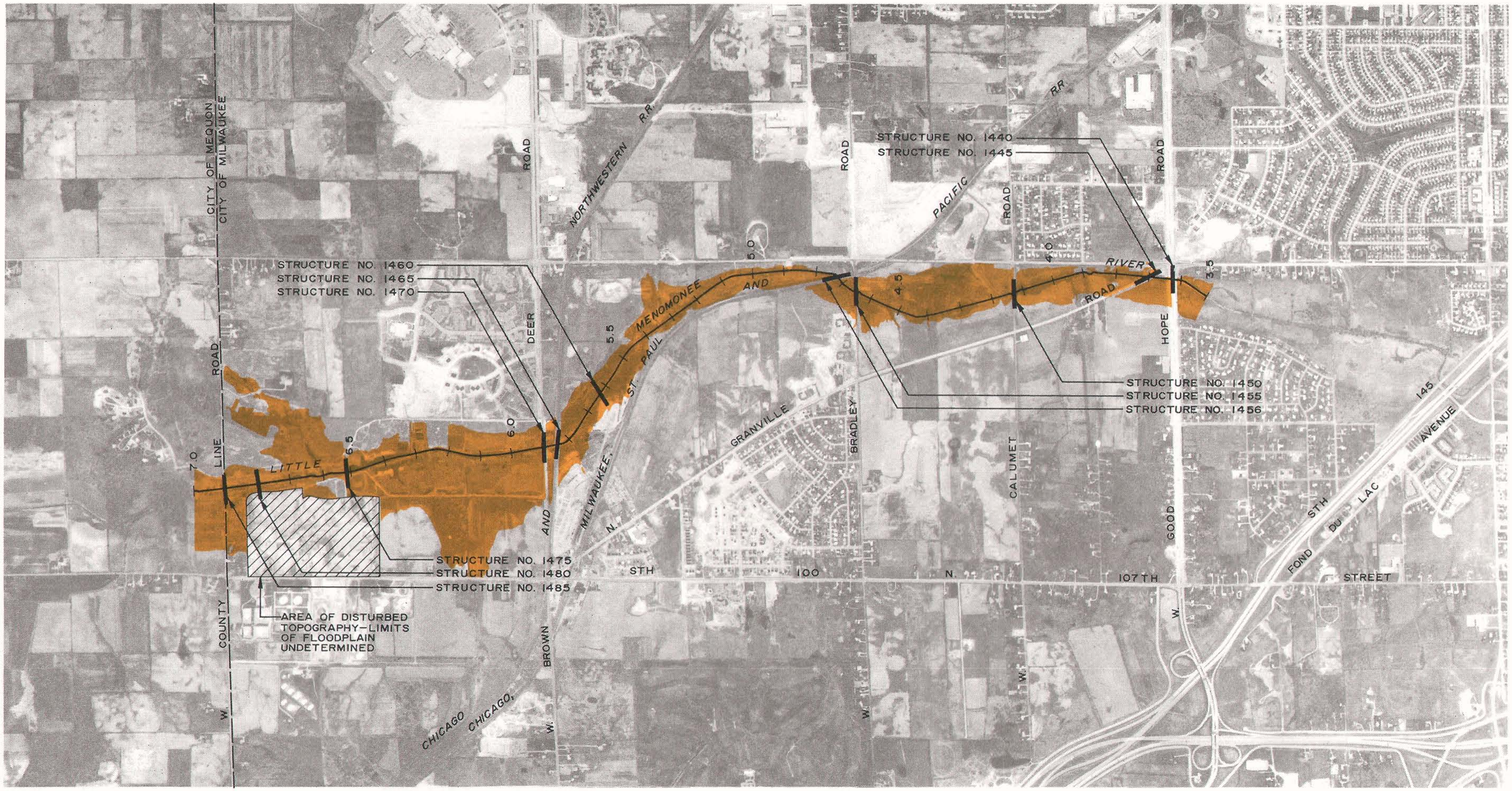
FLOOD STAGE AND STREAMBED PROFILE FOR THE LITTLE MENOMONEE RIVER (R. M. 0.00 to 3.50)



Source: SEWRPC.

Map D-15

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE LITTLE MENOMONEE RIVER (R. M. 3.50 to 7.00)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

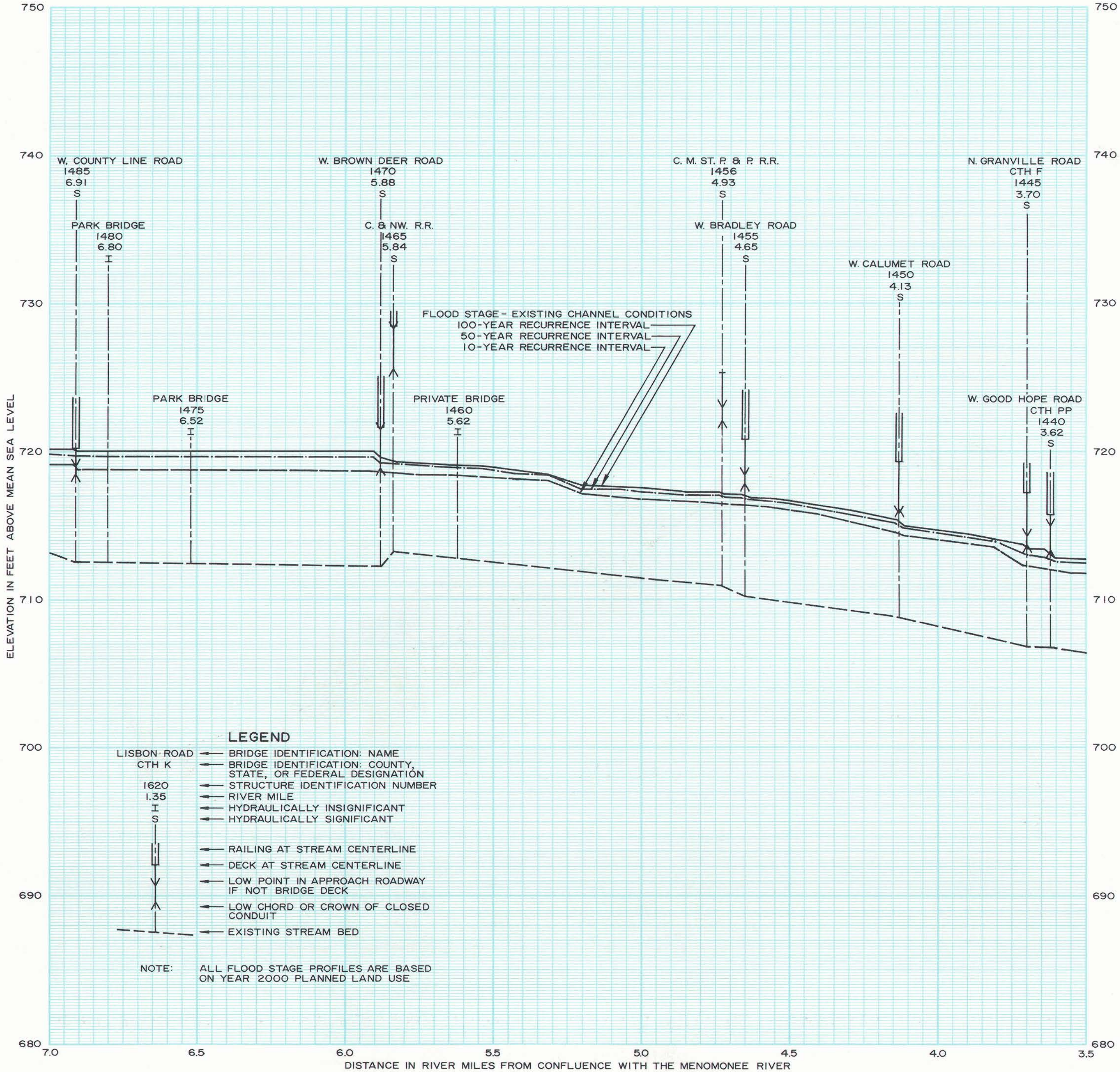
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-15

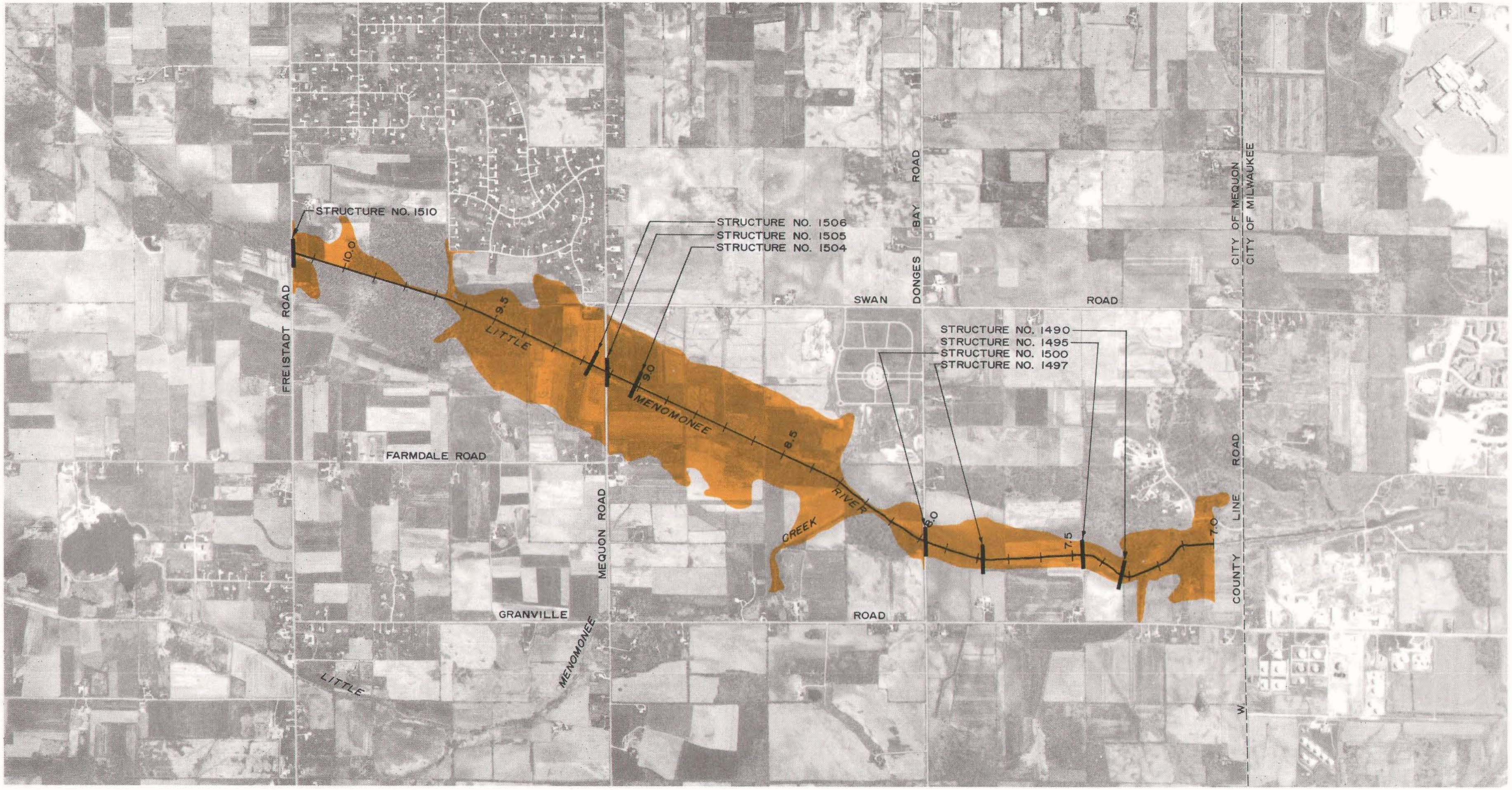
FLOOD STAGE AND STREAMBED PROFILE FOR THE LITTLE MENOMONEE RIVER (R. M. 3.50 to 7.00)



Source: SEWRPC.

Map D-16

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE LITTLE MENOMONEE RIVER (R. M. 7.00 to 10.18)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

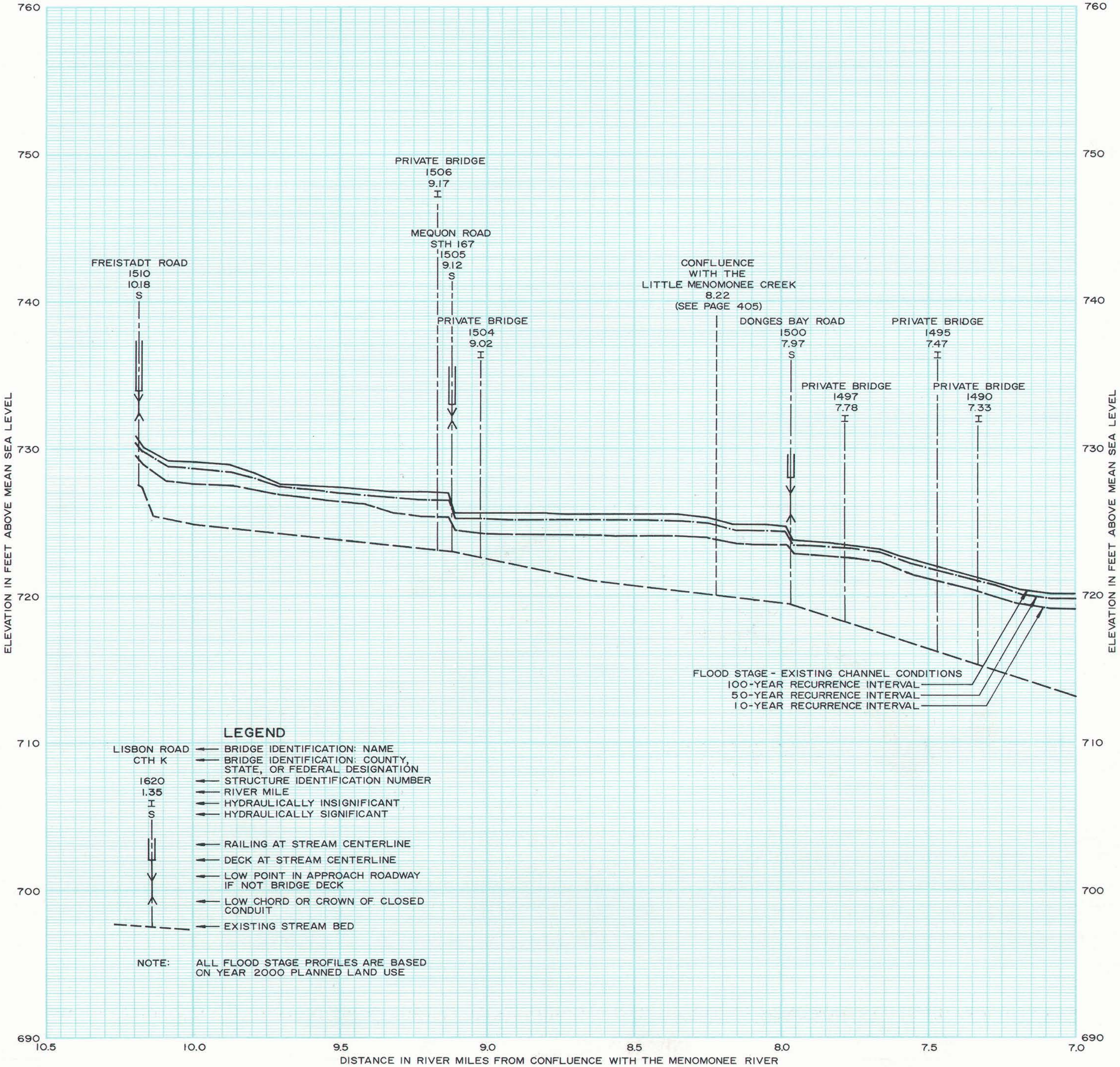
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-16

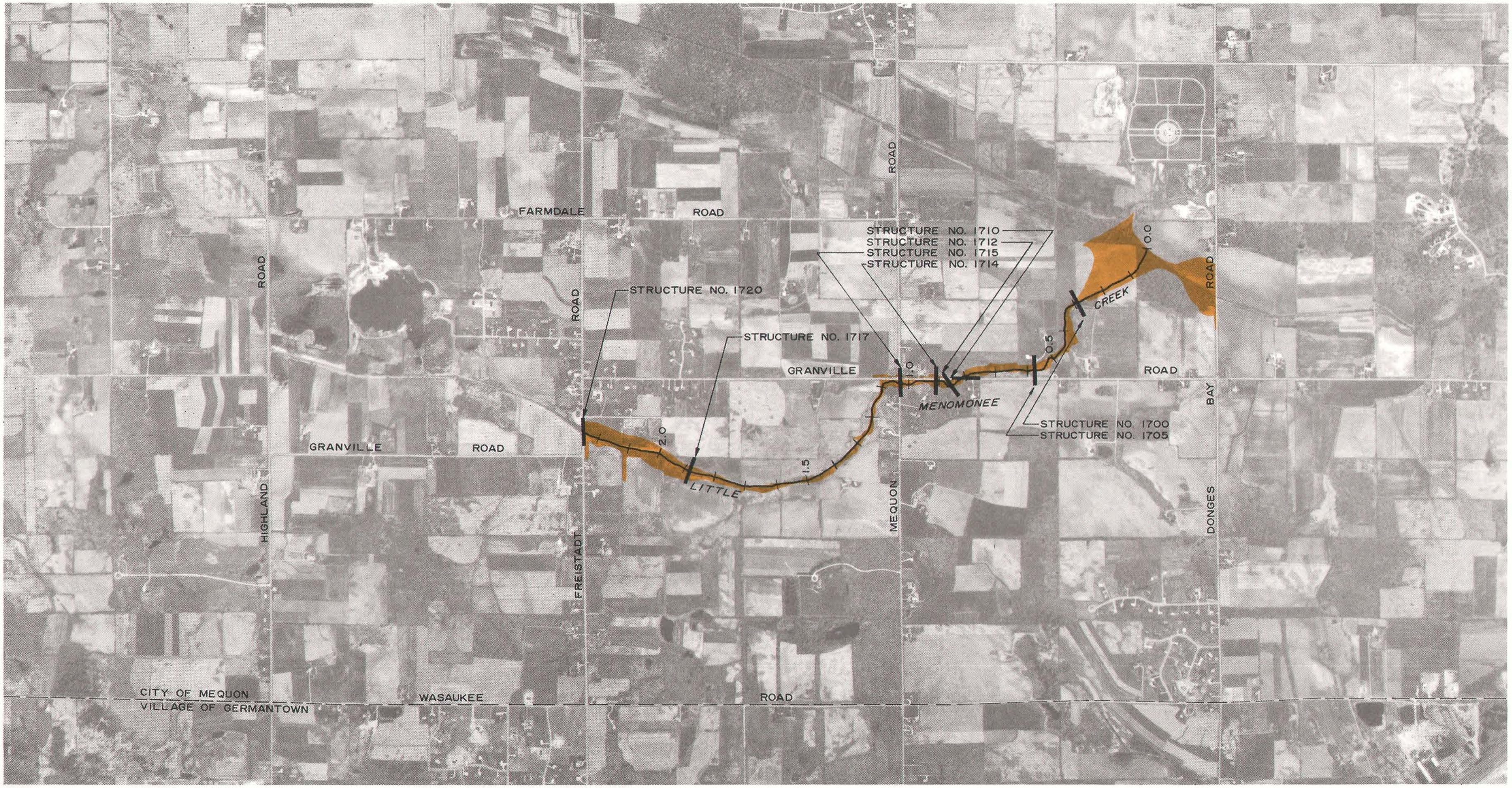
FLOOD STAGE AND STREAMBED PROFILE FOR THE LITTLE MENOMONEE RIVER (R. M. 7.00 to 10.18)



Source: SEWRPC.

Map D-17

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE LITTLE MENOMONEE CREEK (R. M. 0.00 to 2.25)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

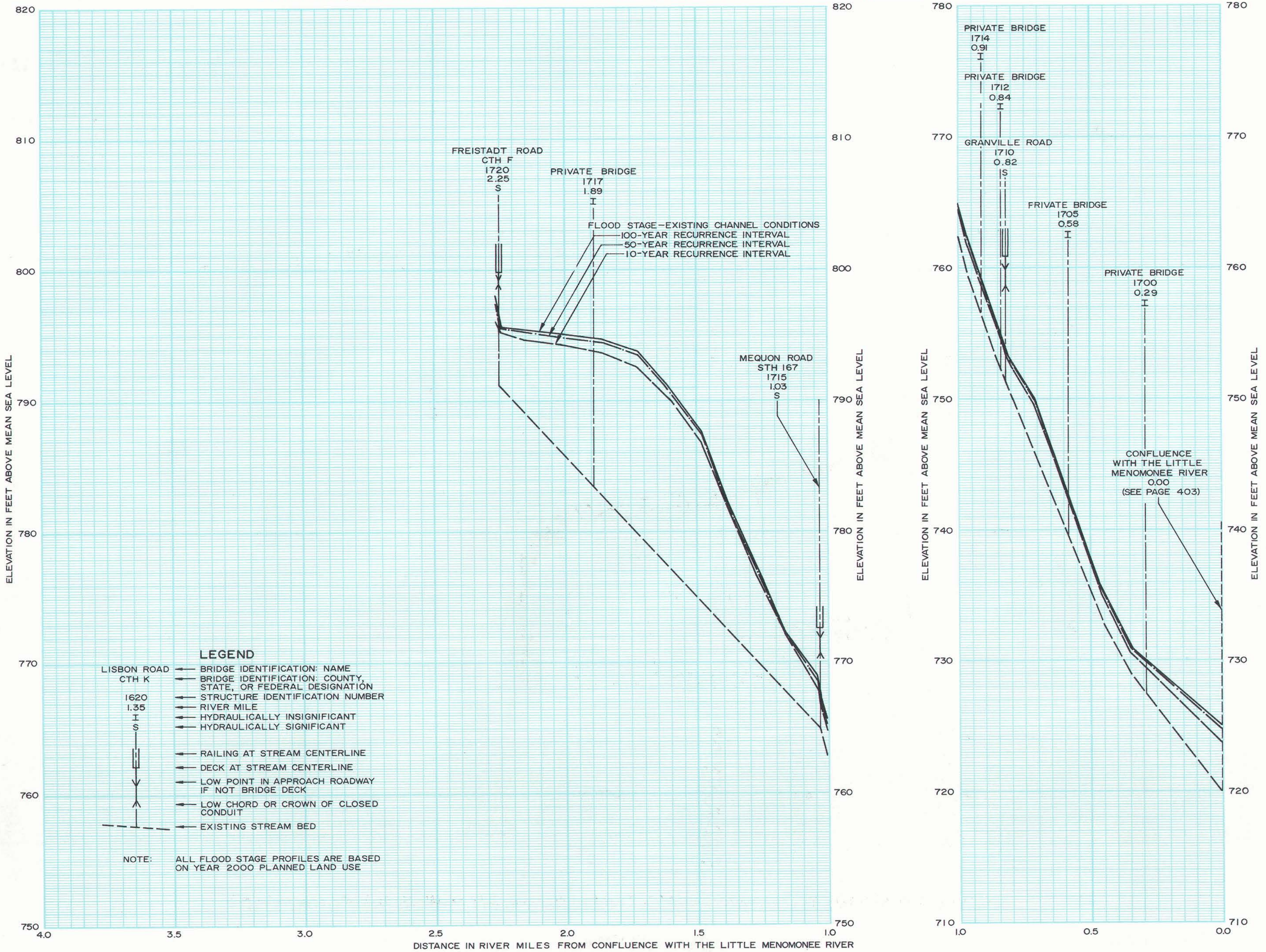
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-17

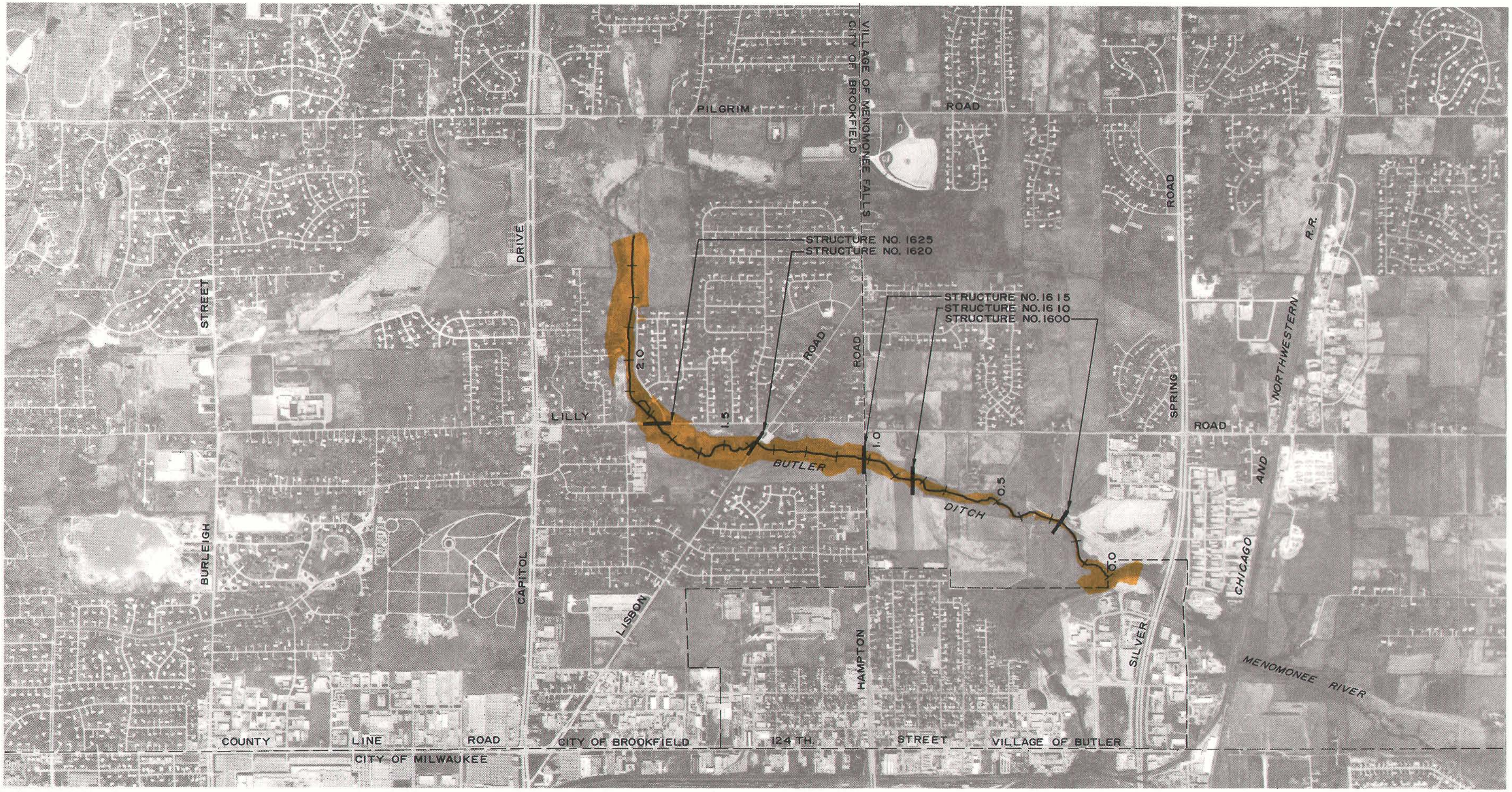
FLOOD STAGE AND STREAMBED PROFILE FOR THE LITTLE MENOMONEE CREEK (R. M. 0.00 to 2.25)



Source: SEWRPC.

Map D-18

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG BUTLER DITCH (R. M. 0.00 to 2.37)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

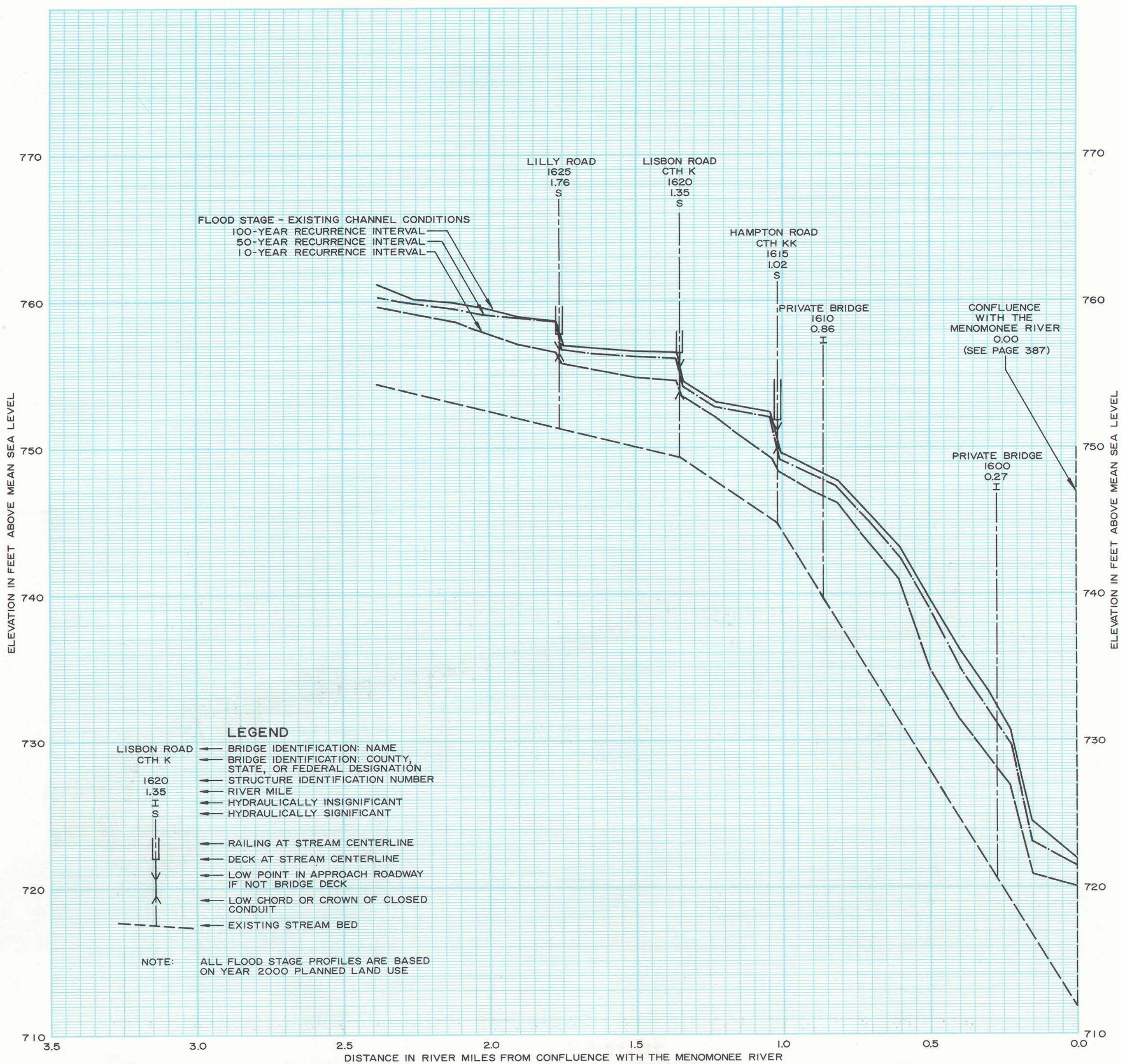
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-18

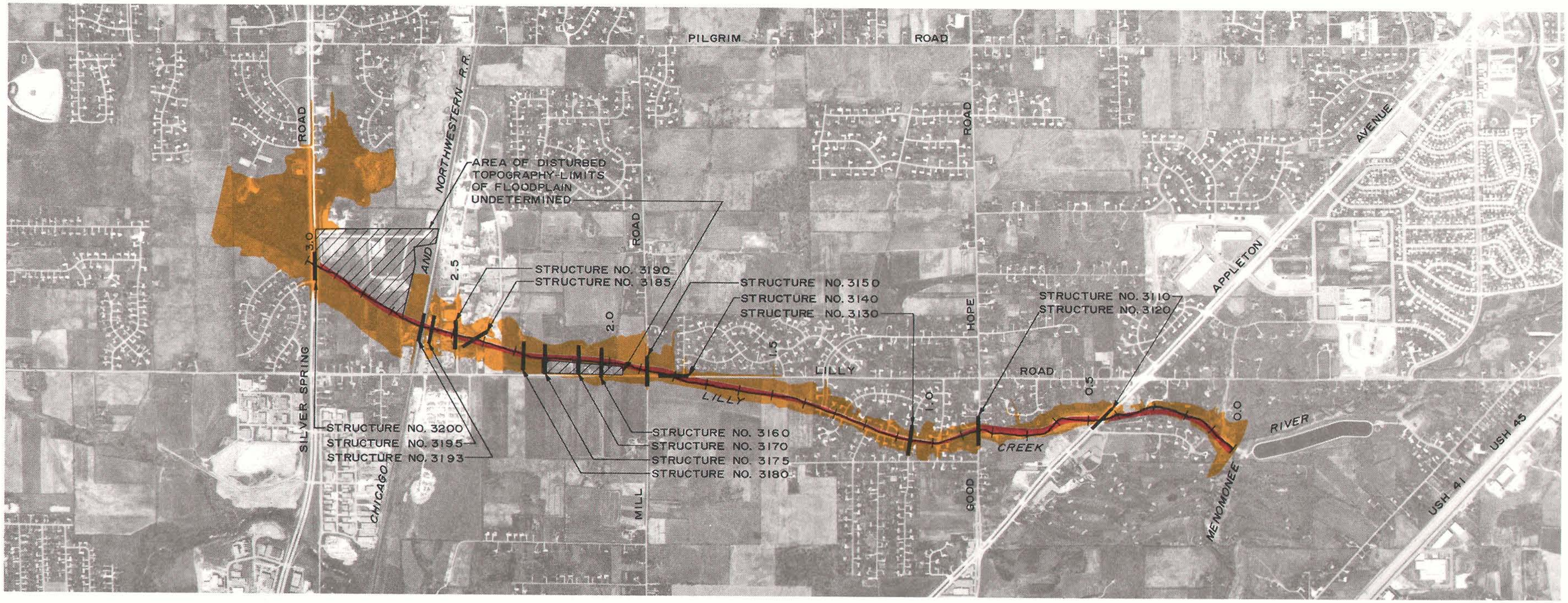
FLOOD STAGE AND STREAMBED PROFILE FOR BUTLER DITCH (R. M. 0.00 to 2.37)

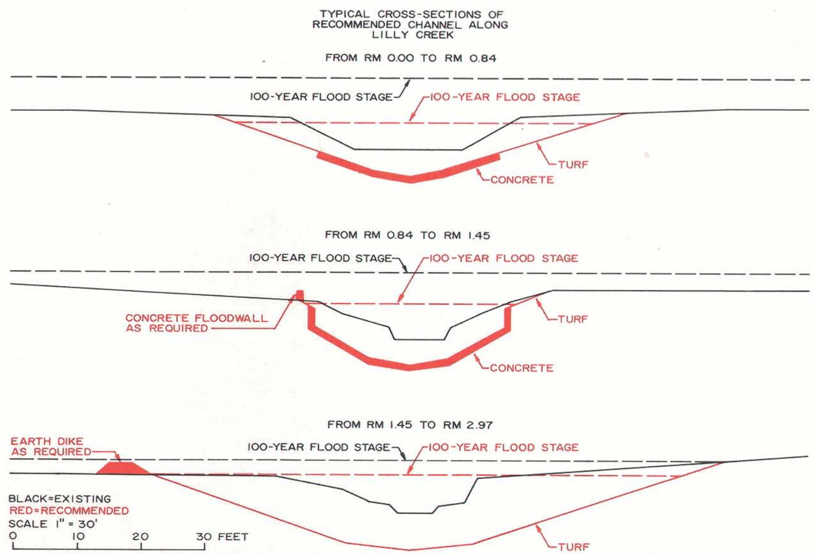


Source: SEWRPC.

Map D-19

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG LILLY CREEK (R. M. 0.00 to 3.29)





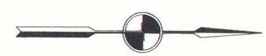
LEGEND

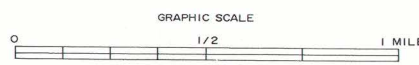
APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

APPROXIMATE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

Source: SEWRPC.

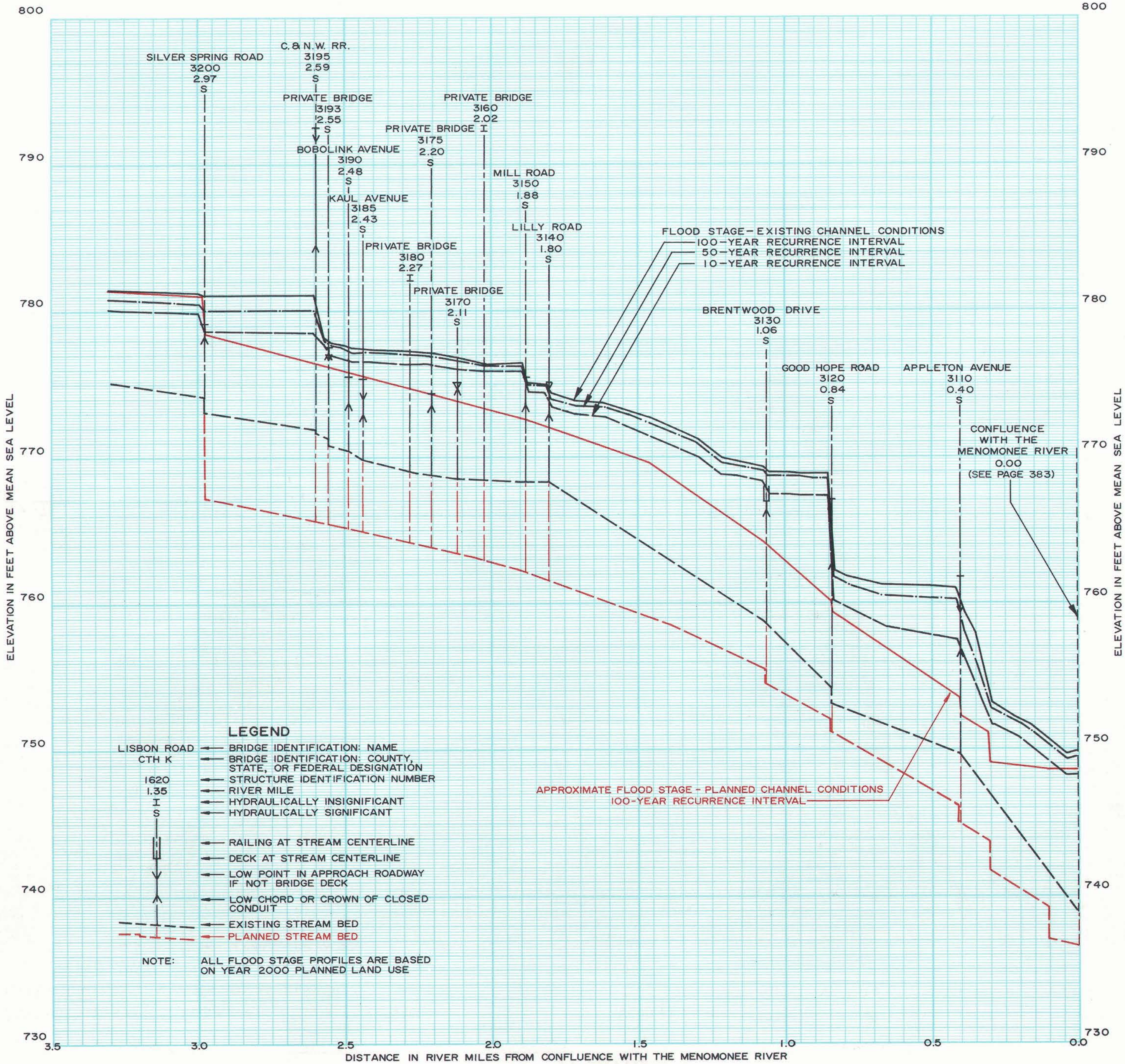




DATE OF PHOTOGRAPHY: MAY 1975

Figure D-19

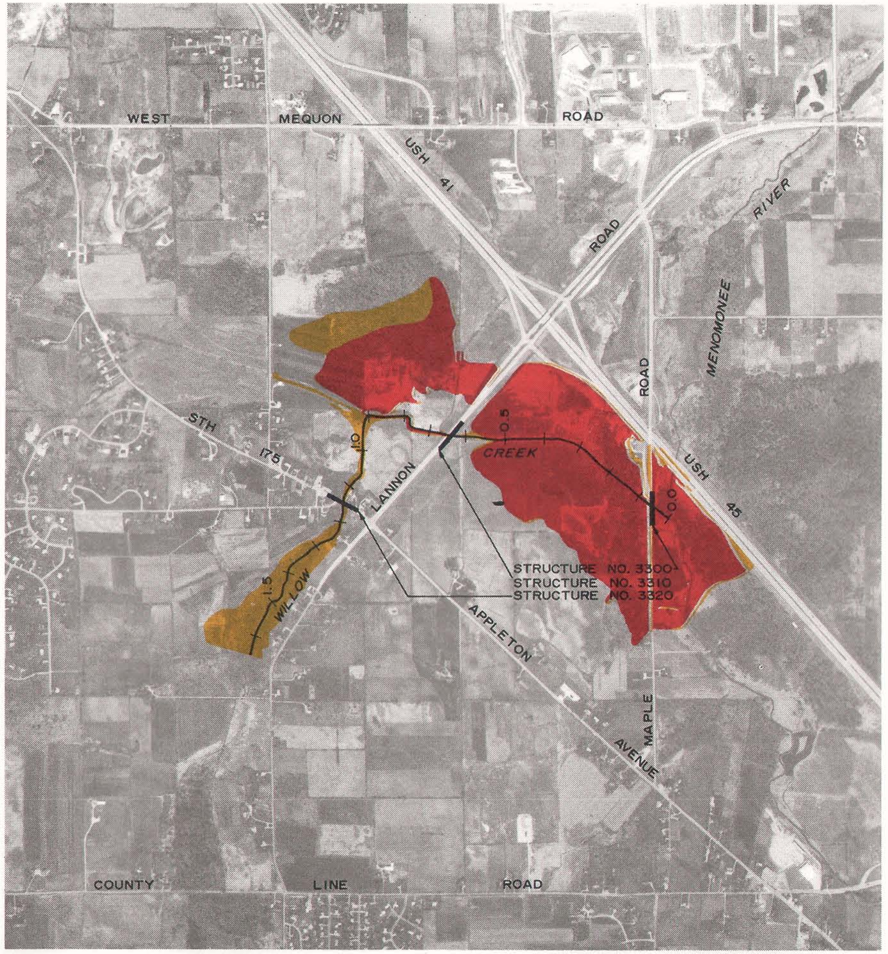
FLOOD STAGE AND STREAMBED PROFILE FOR LILLY CREEK (R. M. 0.00 to 3.29)



Source: SEWRPC.

Map D-21

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG WILLOW CREEK (R. M. 0.00 to 1.65)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

APPROXIMATE 100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND PLANNED CHANNEL CONDITIONS

GRAPHIC SCALE

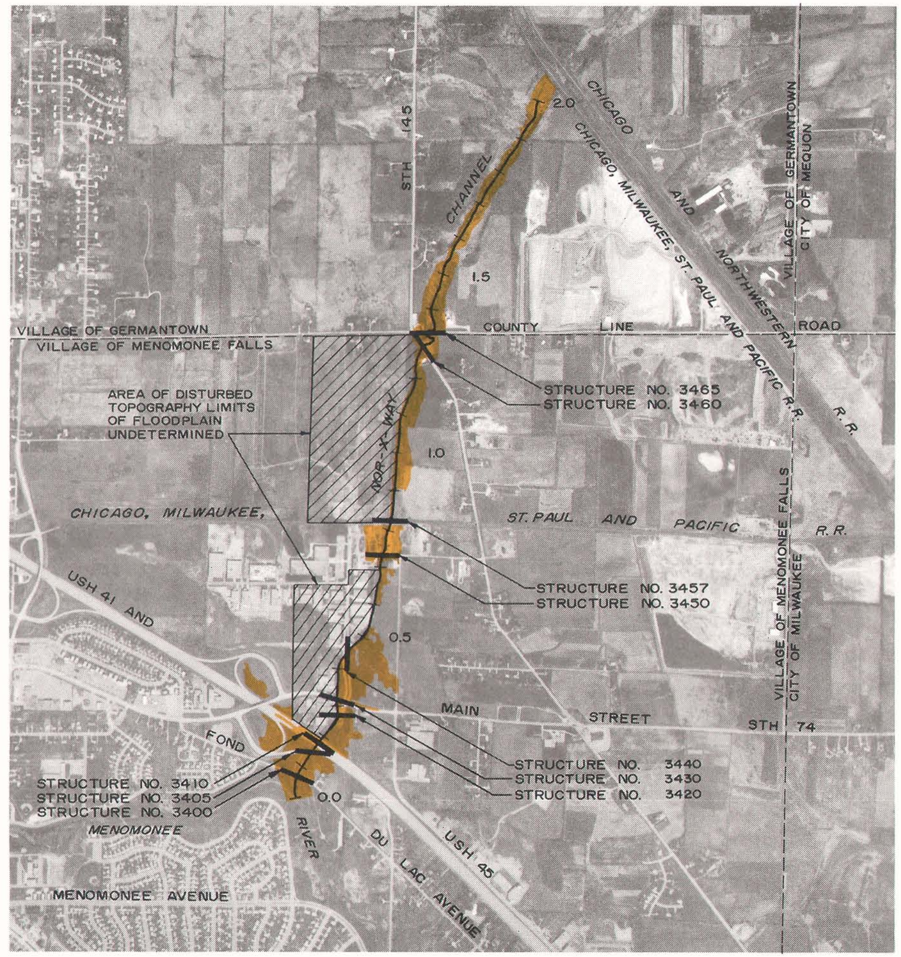
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Map D-20

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE NOR-X-WAY CHANNEL (R. M. 0.00 to 2.08)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

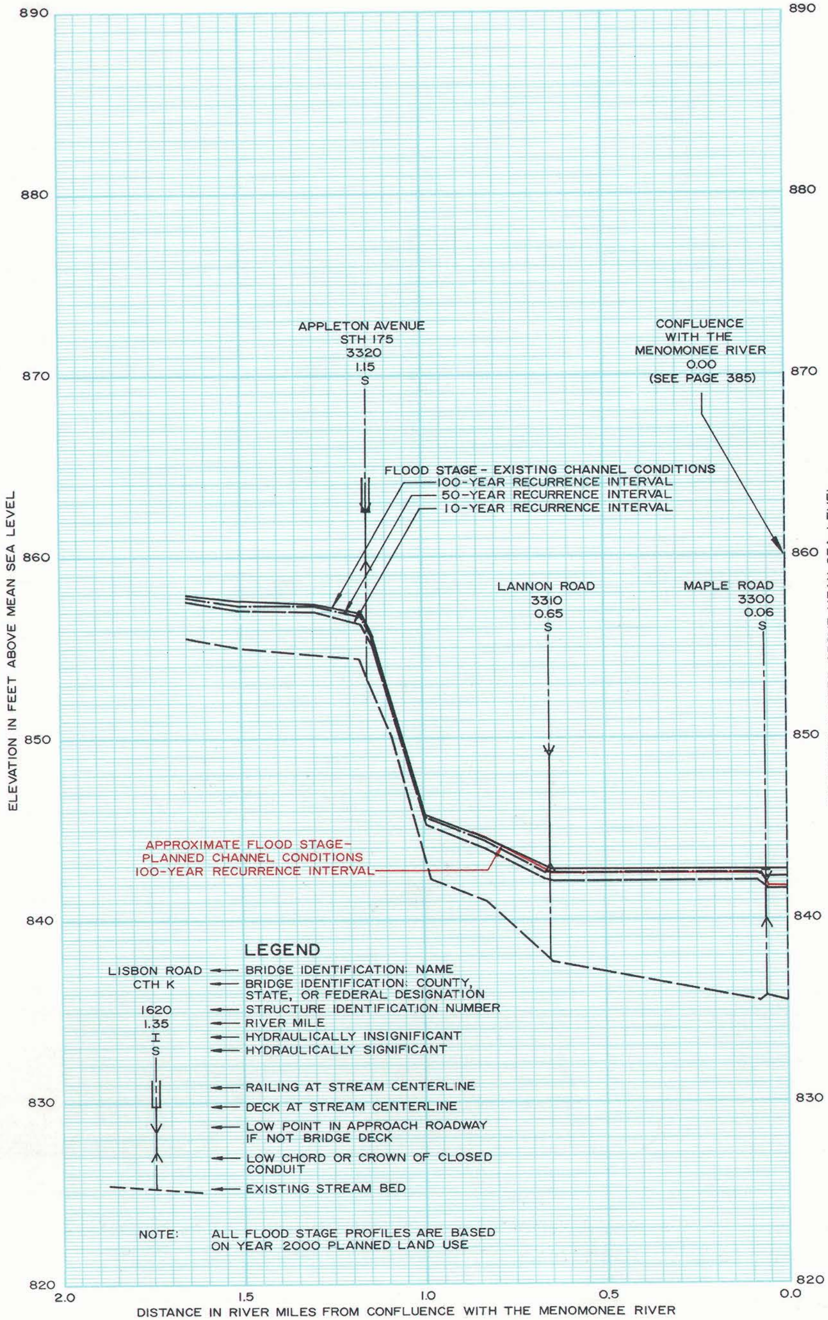
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-21

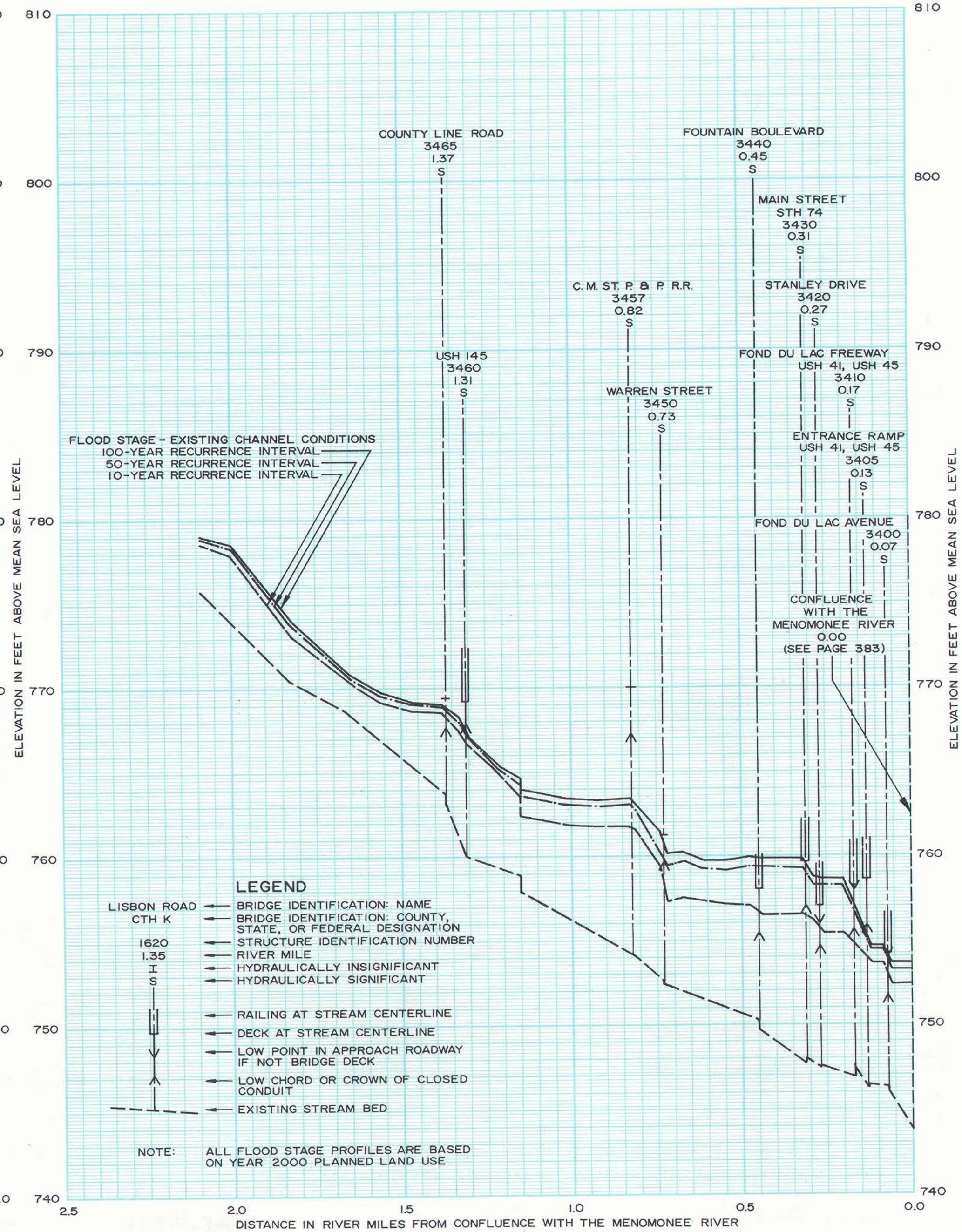
FLOOD STAGE AND STREAMBED PROFILE FOR WILLOW CREEK (R. M. 0.00 to 1.65)



Source: SEWRPC

Figure D-20

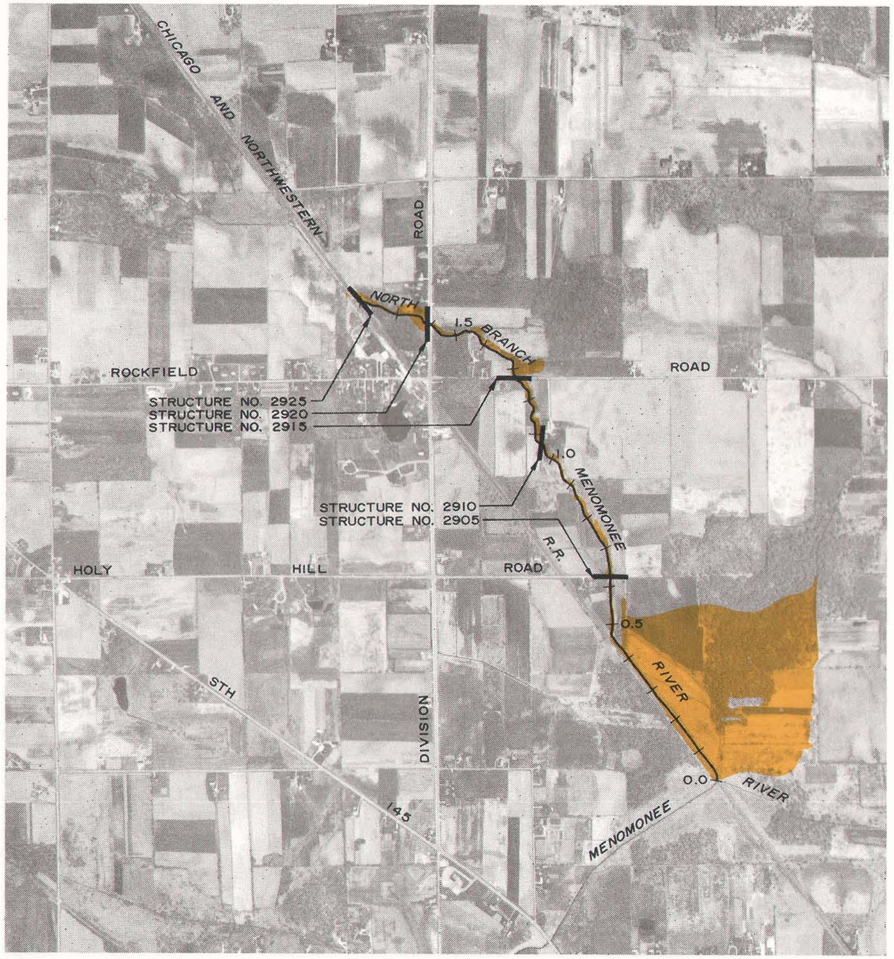
FLOOD STAGE AND STREAMBED PROFILE FOR THE NOR-X-WAY CHANNEL (R. M. 0.00 to 2.08)



Source: SEWRPC

Map D-23

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE NORTH BRANCH OF THE MENOMONEE RIVER (R. M. 0.00 to 1.83)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

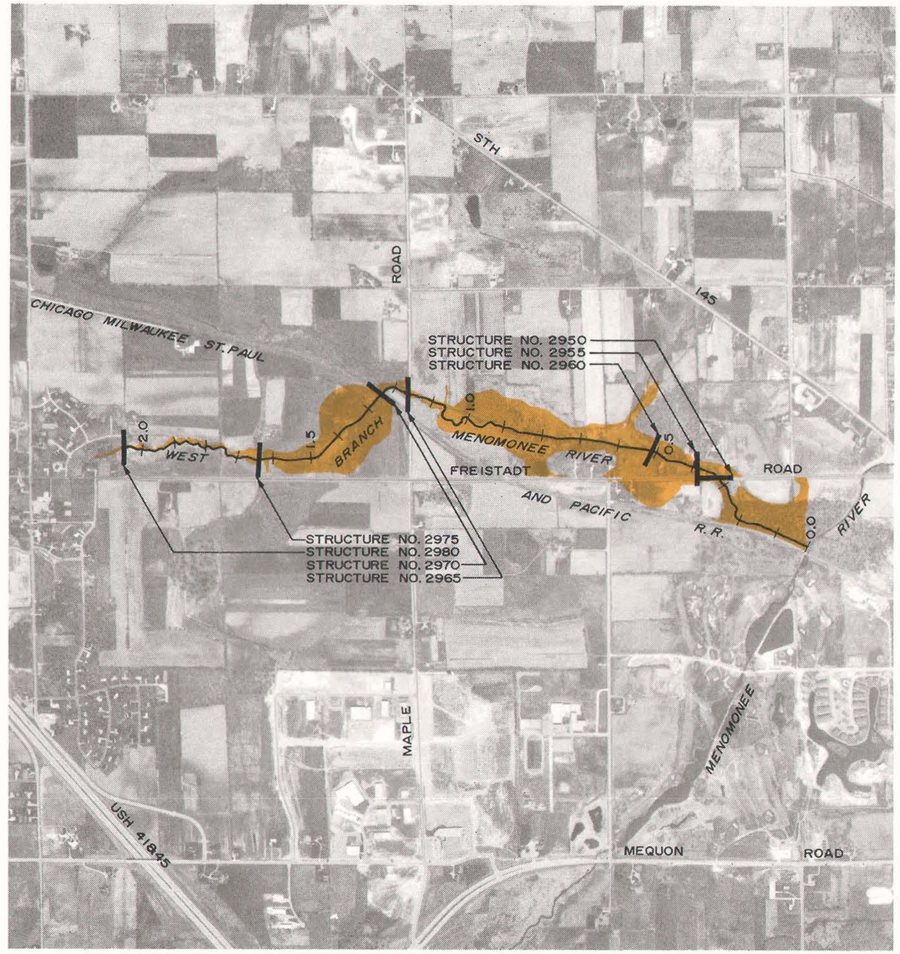
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Map D-22

AERIAL PHOTOGRAPH SHOWING AREAS SUBJECT TO FLOODING ALONG THE WEST BRANCH OF THE MENOMONEE RIVER (R. M. 0.00 to 2.05)



LEGEND

APPROXIMATE EXISTING CHANNEL CENTERLINE AND RIVER MILE STATIONING

100-YEAR RECURRENCE INTERVAL FLOODPLAIN--PLANNED LAND USE AND EXISTING CHANNEL CONDITIONS

GRAPHIC SCALE

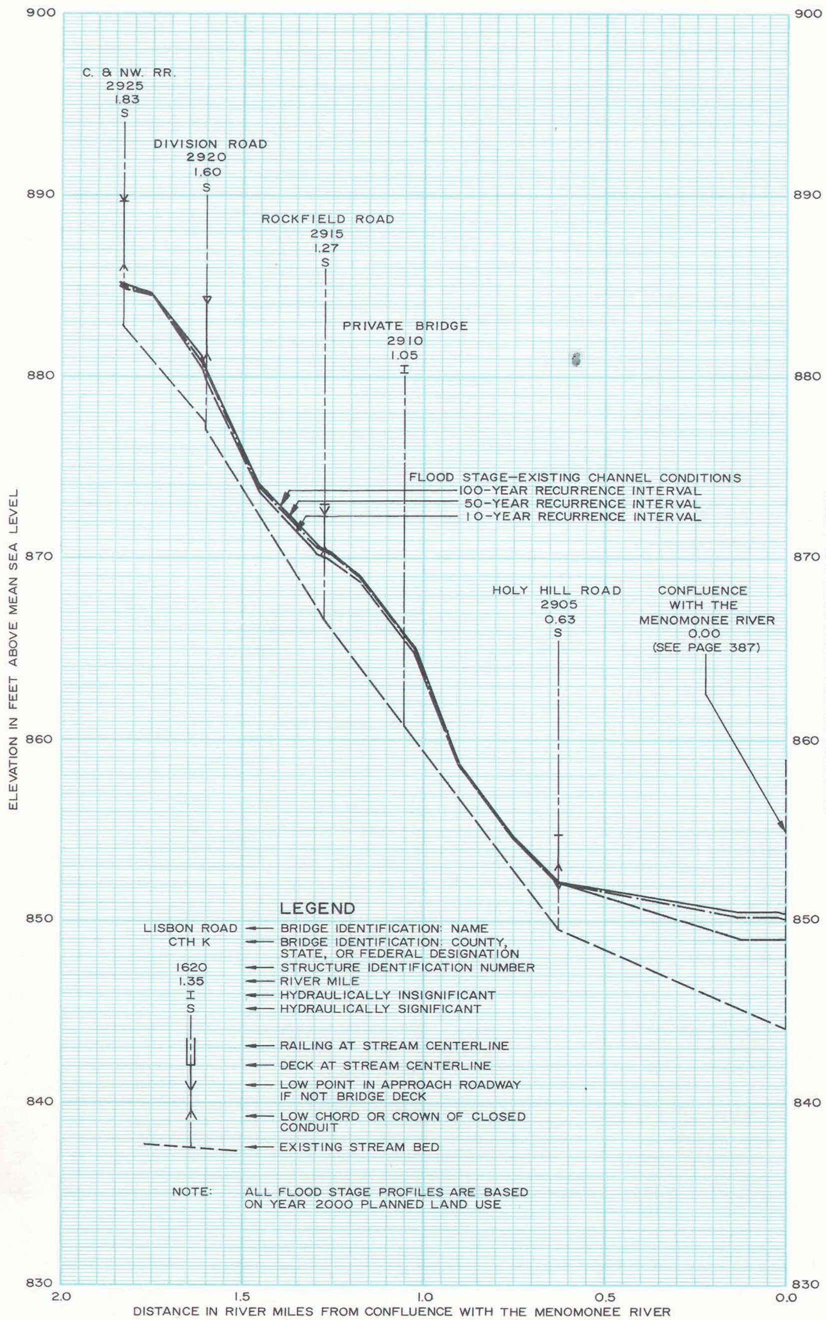
0 1/2 1 MILE

DATE OF PHOTOGRAPHY: MAY 1975

Source: SEWRPC.

Figure D-23

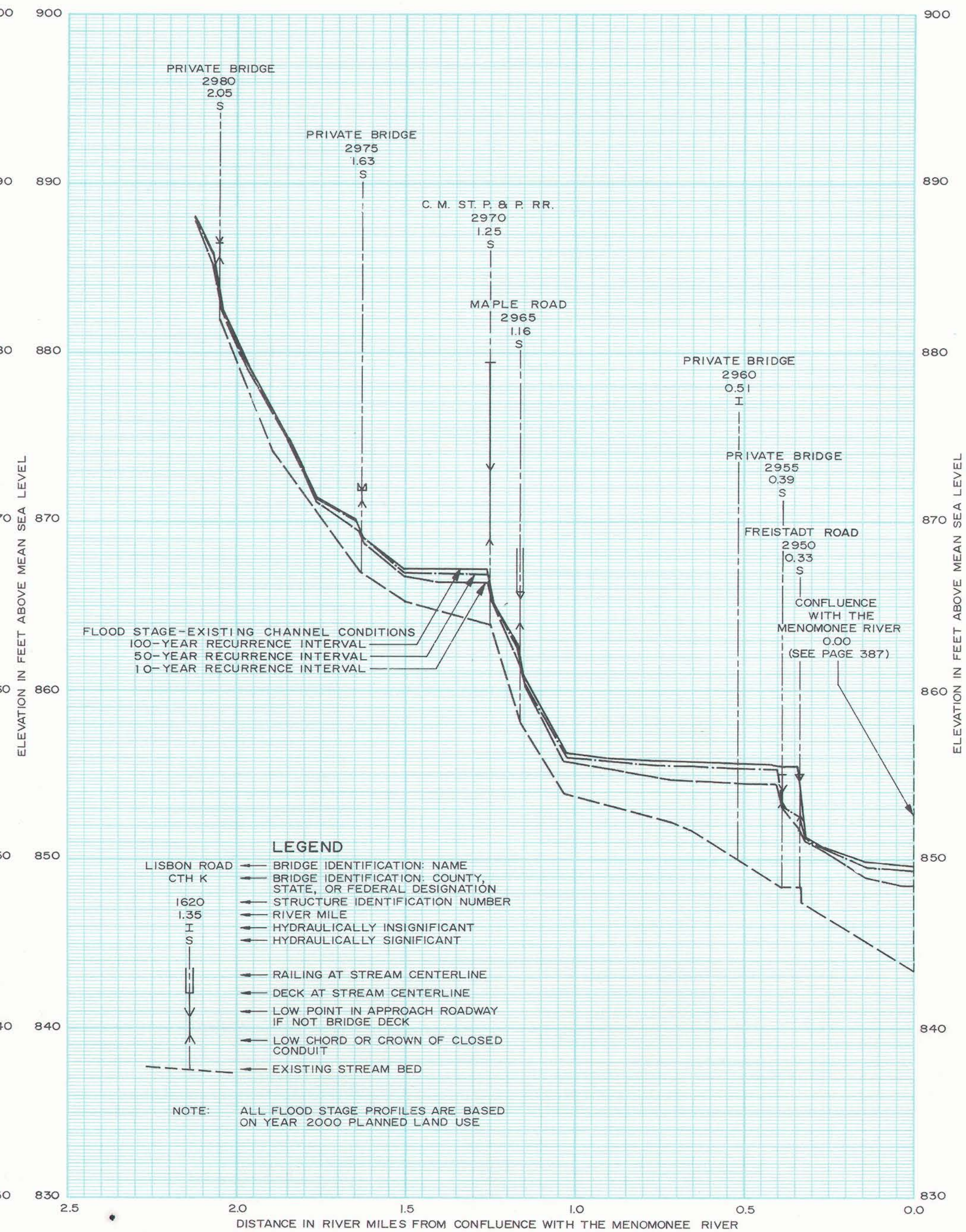
FLOOD STAGE AND STREAMBED PROFILE FOR THE NORTH BRANCH OF THE MENOMONEE RIVER (R. M. 0.00 to 1.83)



Source: SEWRPC

Figure D-22

FLOOD STAGE AND STREAMBED PROFILE FOR THE WEST BRANCH OF THE MENOMONEE RIVER (R. M. 0.00 to 2.05)



Source: SEWRPC

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Appendix E

HYDROLOGIC-HYDRAULIC SUMMARY FOR STRUCTURES ON THE MENOMONEE RIVER AND SELECTED MAJOR TRIBUTARIES

Table E-1

HYDROLOGIC-HYDRAULIC SUMMARY—LOWER MENOMONEE RIVER

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
500	Chicago, Milwaukee, St. Paul, and Pacific Railroad	0.02	1I	--	N/A	N/A	10,900	N/A	N/A	N/A	N/A	N/A	16,400	N/A	N/A	N/A	N/A	N/A	19,600	N/A	N/A	N/A	N/A	N/A
505	Plankinton Avenue	0.06	1I	--	N/A	N/A	10,900	N/A	N/A	N/A	N/A	N/A	16,400	N/A	N/A	N/A	N/A	N/A	19,600	N/A	N/A	N/A	N/A	N/A
510	6th Street	0.35	1I	--	N/A	N/A	10,900	N/A	N/A	N/A	N/A	N/A	16,400	N/A	N/A	N/A	N/A	N/A	19,600	N/A	N/A	N/A	N/A	N/A
515	North-South Freeway (I 94)	0.58	1I	--	N/A	N/A	10,900	N/A	N/A	N/A	N/A	N/A	16,400	N/A	N/A	N/A	N/A	N/A	19,600	N/A	N/A	N/A	N/A	N/A
520	N. Muskego Avenue	0.92	1I	--	N/A	N/A	10,900	N/A	N/A	N/A	N/A	N/A	16,400	N/A	N/A	N/A	N/A	N/A	19,600	N/A	N/A	N/A	N/A	N/A
525	16th Street	1.11	1I	--	N/A	N/A	10,900	N/A	N/A	N/A	N/A	N/A	16,400	N/A	N/A	N/A	N/A	N/A	19,600	N/A	N/A	N/A	N/A	N/A
530	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.87	1S	--	100	No	10,900	585.5	584.5	0.8	-0.2	-3.2	16,400	587.0	586.0	0.4	1.3	-1.7	19,600	587.7	587.5	0.0	1.9	-1.1
535	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.91	1S	--	100	No	10,900	586.2	585.6	0.5	1.7	-2.5	16,400	587.2	587.0	0.2	2.6	-1.6	19,600	587.9	587.7	0.2	3.3	-0.9
540	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.95	1S	--	100	No	10,900	587.0	586.1	0.8	0.7	-3.2	16,400	587.7	587.1	0.5	1.1	-2.8	19,600	588.1	587.8	0.2	1.8	-2.1
542	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.97	1S	--	100	No	10,900	588.1	587.0	0.0	-0.1	-2.7	16,400	588.4	587.7	0.0	0.2	-2.4	19,600	588.4	588.1	0.0	0.2	-2.4
545	27th Street	2.10	1I	--	N/A	N/A	10,900	N/A	N/A	N/A	N/A	N/A	16,400	N/A	N/A	N/A	N/A	N/A	19,600	N/A	N/A	N/A	N/A	N/A
546	Falk Dam	2.22	2S	--	N/A	N/A	10,900	590.6	588.1	N/A	N/A	N/A	16,400	593.2	588.2	N/A	N/A	N/A	19,600	594.5	588.6	N/A	N/A	N/A
550	Chicago, Milwaukee, St. Paul, and Pacific Railroad	2.50	1S	--	100	Yes	10,300	592.6	591.4	1.1	-5.2	-12.5	15,700	595.6	594.1	1.4	-2.0	-9.3	18,400	597.2	595.5	1.5	-0.3	-7.3
555	Chicago, Milwaukee, St. Paul, and Pacific Railroad	2.60	1S	--	100	Yes	10,300	592.8	592.6	0.2	-7.6	-7.6	15,700	596.9	595.8	1.0	-3.6	-3.6	18,400	598.9	597.4	1.4	-1.5	-1.5
560	35th Street	2.65	1I	--	N/A	N/A	10,300	N/A	N/A	N/A	N/A	N/A	15,700	N/A	N/A	N/A	N/A	N/A	18,400	N/A	N/A	N/A	N/A	N/A
565	Pedestrian Bridge	2.78	1I	--	N/A	N/A	10,300	N/A	N/A	N/A	N/A	N/A	15,700	N/A	N/A	N/A	N/A	N/A	18,400	N/A	N/A	N/A	N/A	N/A
570	Pedestrian Bridge	3.22	1I	--	N/A	N/A	10,300	N/A	N/A	N/A	N/A	N/A	15,700	N/A	N/A	N/A	N/A	N/A	18,400	N/A	N/A	N/A	N/A	N/A
575	East-West Freeway (I 94)	3.65	1I	--	N/A	N/A	10,300	N/A	N/A	N/A	N/A	N/A	15,700	N/A	N/A	N/A	N/A	N/A	18,400	N/A	N/A	N/A	N/A	N/A
580	Chicago, Milwaukee, St. Paul, and Pacific Railroad	3.71	1S	1945	100	Yes	9,100	597.1	596.3	0.4	-7.7	-8.2	14,100	601.9	600.0	1.7	-2.7	-3.2	16,800	604.6	601.7	2.8	-0.1	-0.6
584	W. Bluemound Road	4.07	1I	--	N/A	N/A	9,100	N/A	N/A	N/A	N/A	N/A	14,100	N/A	N/A	N/A	N/A	N/A	16,800	N/A	N/A	N/A	N/A	N/A
585	W. Wisconsin Avenue (STH 18)	4.08	1I	--	N/A	N/A	9,100	N/A	N/A	N/A	N/A	N/A	14,100	N/A	N/A	N/A	N/A	N/A	16,800	N/A	N/A	N/A	N/A	N/A
590	Chicago, Milwaukee, St. Paul, and Pacific Railroad	4.24	1S	--	100	No	9,100	606.6	601.9	4.6	-7.7	-9.8	14,100	612.6	604.8	7.7	-1.8	-3.9	16,800	615.5	606.4	9.1	1.0	-1.1
595	Pedestrian Bridge	4.43	1I	--	N/A	N/A	9,100	N/A	N/A	N/A	N/A	N/A	14,100	N/A	N/A	N/A	N/A	N/A	16,800	N/A	N/A	N/A	N/A	N/A
600	N. 45th Street	4.45	1S	--	10	Yes	9,100	611.6	608.8	2.3	-6.0	-6.0	14,100	616.6	612.1	4.4	-3.0	-3.0	16,800	619.2	614.6	4.6	-0.7	-0.7
605	Chicago, Milwaukee, St. Paul, and Pacific Railroad	4.56	1S	--	100	No	9,100	617.2	615.6	0.9	0.2	-0.4	14,100	620.8	618.4	1.8	1.3	0.7	16,800	622.5	619.9	2.3	3.0	2.4
610	Stadium Freeway (USH 41)	4.63	1S	--	100	Yes	9,100	619.8	619.4	0.0	-36.4	-36.4	14,100	624.9	624.5	0.0	-31.5	-31.5	16,800	625.9	625.8	0.0	-29.9	-29.9
615	Private Bridge	4.83	1I	--	N/A	N/A	9,100	N/A	N/A	N/A	N/A	N/A	14,100	N/A	N/A	N/A	N/A	N/A	16,800	N/A	N/A	N/A	N/A	N/A
620	Hawley Road	5.15	1I	--	N/A	N/A	9,050	N/A	N/A	N/A	N/A	N/A	14,100	N/A	N/A	N/A	N/A	N/A	16,800	N/A	N/A	N/A	N/A	N/A
620A	Hawley Road	5.15	1S	--	10	Yes	9,050	628.9	628.2	0.0	-0.5	-5.2	14,100	633.4	630.5	1.8	4.2	-1.0	16,800	634.0	631.6	2.1	4.6	-0.6
625	Pedestrian Bridge	5.66	1I	--	N/A	N/A	9,050	N/A	N/A	N/A	N/A	N/A	14,100	N/A	N/A	N/A	N/A	N/A	16,800	N/A	N/A	N/A	N/A	N/A
630	N. 68th Street	5.96	1S	--	50	No	9,050	640.6	639.8	0.0	-0.6	-2.7	14,100	642.4	641.9	0.0	1.4	-0.7	16,800	643.3	642.9	0.0	1.6	-0.3
635	N. 70th Street	6.10	1S	--	10	No	9,050	644.3	643.3	0.0	0.9	-1.0	14,100	644.6	644.0	0.0	1.6	-0.3	16,800	645.2	644.8	0.0	2.3	0.4
640	Chicago, Milwaukee, St. Paul, and Pacific Railroad	6.70	1S	1905	100	No	6,800	650.9	650.0	0.7	-3.0	-4.3	10,600	653.4	651.8	1.4	0.9	-0.3	12,700	654.3	652.4	1.8	1.9	0.6
645	Harwood Avenue	6.72	1S	--	50	Yes	6,800	651.9	650.9	0.0	-4.9	-9.4	10,600	655.5	653.4	0.0	-1.0	-5.5	12,700	656.2	654.3	0.0	-0.1	-4.6
646	Ford	7.23	4I	--	N/A	N/A	6,800	N/A	N/A	N/A	N/A	N/A	10,600	N/A	N/A	N/A	N/A	N/A	12,700	N/A	N/A	N/A	N/A	N/A
648	Pedestrian Bridge	7.69	1I	--	N/A	N/A	6,800	N/A	N/A	N/A	N/A	N/A	10,600	N/A	N/A	N/A	N/A	N/A	12,700	N/A	N/A	N/A	N/A	N/A
649	Paved Ford	7.82	4I	--	N/A	N/A	6,800	N/A	N/A	N/A	N/A	N/A	10,600	N/A	N/A	N/A	N/A	N/A	12,700	N/A	N/A	N/A	N/A	N/A
650	Swan Boulevard	8.00	1S	--	50	No	6,800	671.5	670.2	0.6	6.9	-3.5	10,600	675.0	672.7	1.7	10.5	0.1	12,700	675.6	673.8	1.2	11.2	0.8
655	Paved Ford	8.33	4S	--	N/A	N/A	6,800	N/A	N/A	N/A	N/A	N/A	10,600	N/A	N/A	N/A	N/A	N/A	12,700	N/A	N/A	N/A	N/A	N/A
660	North Avenue	8.50	1S	1934	50	No	4,230	676.7	676.2	0.5	-3.2	-3.3	6,050	680.0	679.2	0.8	0.1	0.0	6,900	681.6	680.5	1.0	1.8	1.7
665	Burleigh Street	9.68	1S	--	50	Yes	4,230	685.0	684.7	0.0	-5.0	-5.0	6,050	687.4	686.2	0.8	-2.6	-2.6	6,900	688.4	686.8	1.2	-2.3	-2.3
667	Limestone Ford	10.21	4I	--	N/A	N/A	3,870	N/A	N/A	N/A	N/A	N/A	5,550	N/A	N/A	N/A	N/A	N/A	6,350	N/A	N/A	N/A	N/A	N/A
670	Mayfair Road	10.67	1S	1968	50	Yes	3,870	691.1	691.9	0.0	-7.3	-7.7	5,550	692.7	693.6	0.0	-5.6	-6.0	6,350	693.4	694.2	0.0	-4.9	-5.3
679	Pedestrian Bridge	10.90	1I	--	N/A	N/A	3,870	N/A	N/A	N/A	N/A	N/A	5,550	N/A	N/A	N/A	N/A	N/A	6,350	N/A	N/A	N/A	N/A	N/A
680	Private Bridge	10.94	1I	--	N/A	N/A	3,870	N/A	N/A	N/A	N/A	N/A	5,550	N/A	N/A	N/A	N/A	N/A	6,350	N/A	N/A	N/A	N/A	N/A
685	Capitol Drive (STH 190)	11.20	1I	1964	N/A	N/A	3,870	N/A	N/A	N/A	N/A	N/A	5,550	N/A	N/A	N/A	N/A	N/A	6,350	N/A	N/A	N/A	N/A	N/A
685A	Capitol Drive Arch Bridge	11.20	1S	--	50	Yes	3,870	698.7	697.8	0.8	-8.0	-8.4	5,550	700.7	699.2	1.4	-6.4	-6.8	6,350	701.6	699.6	1.8	-5.8	-6.2
690	W. Hampton Avenue	12.52	1S	1968	50	Yes	3,330	701.0	700.6	0.4	-10.2	-13.6	4,750	702.8	702.4	0.4	-8.5	-11.9	5,450	703.6	703.2	0.4	-7.7	-11.1

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-2

HYDROLOGIC-HYDRAULIC SUMMARY—UPPER MENOMONEE RIVER

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions							50-Year Recurrence Interval Flood—2000 Land Use Conditions							100-Year Recurrence Interval Flood—2000 Land Use Conditions						
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
695	Zoo Freeway (USH 45)	12.88	1S	--	100	Yes	2,830	705.0	704.9	0.0	-13.3	-13.3	4,130	705.8	705.7	0.0	-12.5	-12.5	4,730	706.3	706.2	0.0	-12.0	-12.0
700	Chicago and Northwestern Railroad	13.42	1S	--	100	Yes	2,830	708.7	708.5	0.0	-31.8	-36.3	4,130	710.2	709.7	0.3	-30.6	-35.1	4,730	710.8	710.1	0.5	-30.0	-34.5
705	N. 124th Street	13.52	1S	--	50	Yes	2,830	709.6	708.9	0.6	-3.2	-3.3	4,130	712.0	710.2	1.8	-0.7	-0.8	4,730	713.2	710.7	2.4	0.2	0.1
706	Pedestrian Bridge	13.80	1I	--	N/A	N/A	2,830	N/A	N/A	N/A	N/A	N/A	4,130	N/A	N/A	N/A	N/A	N/A	4,730	N/A	N/A	N/A	N/A	N/A
710	W. Silver Spring Drive (CTH VV)	14.64	1S	1964	50	Yes	2,360	723.2	723.2	0.0	-25.5	-27.1	3,270	724.6	724.4	0.0	-24.1	-25.7	3,680	725.1	724.9	0.0	-23.6	-25.2
715	Silver Spring Road	14.73	1S	--	10	Yes	2,360	723.7	723.6	0.0	-4.0	-4.5	3,270	725.1	724.9	0.0	-2.6	-3.1	3,680	726.0	725.4	0.5	-1.7	-2.2
720	Chicago and Northwestern Railroad	14.96	1S	--	100	Yes	2,360	725.5	725.2	0.0	-38.8	-38.8	3,270	726.7	726.4	0.0	-37.6	-37.6	3,680	727.4	727.2	0.0	-37.0	-37.0
725	W. Mill Road	15.98	S	--	50	Yes	2,360	731.9	731.4	0.4	-3.1	-5.4	3,270	733.3	732.5	0.7	-2.2	-4.5	3,680	734.3	732.9	1.3	-1.2	-3.5
725A	W. Mill Road	15.98	1I	--	N/A	N/A	2,360	N/A	N/A	N/A	N/A	N/A	3,270	N/A	N/A	N/A	N/A	N/A	3,680	N/A	N/A	N/A	N/A	N/A
730	W. Appleton Avenue (STH 175)	16.65	1S	1971	50	Yes	2,330	735.4	735.3	0.1	-3.5	-6.7	3,240	736.5	736.4	0.1	-2.4	-5.6	3,640	737.1	736.9	0.2	-1.9	-5.1
735	W. Good Hope Road	17.34	1S	--	50	Yes	2,330	739.8	738.9	0.8	-2.7	-4.1	3,240	741.4	739.8	1.6	-1.8	-3.2	3,640	742.1	740.2	1.8	-1.5	-2.9
736	W. Good Hope Road	17.34	1S	--	50	Yes	2,330	739.8	738.9	0.8	-2.7	-4.1	3,240	74.4	739.8	1.6	-1.8	-3.2	3,640	742.1	740.2	1.8	-1.5	-2.9
740	Private Bridge	18.22	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
741	Private Bridge	18.41	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
745	Private Bridge	18.65	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
750	Private Bridge	18.73	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
755	Private Bridge	18.76	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
760	Private Bridge	18.81	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
765	Private Bridge	18.85	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
770	Private Bridge	18.95	1I	--	N/A	N/A	2,240	N/A	N/A	N/A	N/A	N/A	3,160	N/A	N/A	N/A	N/A	N/A	3,580	N/A	N/A	N/A	N/A	N/A
780	Lilly Road	19.74	1S	--	50	Yes	1,260	749.6	749.3	0.3	-4.2	-4.7	1,710	750.6	750.3	0.3	-3.2	-3.7	1,910	751.4	750.8	0.6	-2.4	-2.9
785	Pedestrian Bridge	20.21	1I	--	N/A	N/A	1,260	N/A	N/A	N/A	N/A	N/A	1,710	N/A	N/A	N/A	N/A	N/A	1,910	N/A	N/A	N/A	N/A	N/A
790	Pedestrian Bridge	20.81	1I	--	N/A	N/A	800	N/A	N/A	N/A	N/A	N/A	1,100	N/A	N/A	N/A	N/A	N/A	1,220	N/A	N/A	N/A	N/A	N/A
795	Pilgrim Road	21.13	1S	--	50	Yes	800	762.1	761.1	0.8	-4.3	-5.3	1,100	762.8	761.8	0.9	-3.3	-4.3	1,220	763.4	762.1	1.1	-3.0	-4.0
800	Arthur Avenue	21.48	1S	--	10	Yes	800	771.2	771.0	0.0	-5.3	-6.2	1,100	772.2	771.9	0.0	-4.5	-5.4	1,220	772.5	772.4	0.0	-4.1	-5.0
804	Limestone Drop	21.75	3S	--	N/A	N/A	800	798.5	790.7	N/A	N/A	N/A	1,100	798.5	791.1	N/A	N/A	N/A	1,220	798.5	791.3	N/A	N/A	N/A
805	Pedestrian Bridge	21.82	1I	--	N/A	N/A	800	N/A	N/A	N/A	N/A	N/A	1,100	N/A	N/A	N/A	N/A	N/A	1,220	N/A	N/A	N/A	N/A	N/A
810	Main Street (STH 74)	21.91	1S	--	50	Yes	800	816.4	814.1	0.0	-18.9	-19.7	1,100	817.1	814.7	0.0	-18.7	-19.5	1,220	817.3	814.9	0.0	-18.5	-19.3
815	Menomonee Falls Dam	21.93	2S	--	N/A	N/A	680	834.1	N/A	N/A	N/A	N/A	910	834.7	N/A	N/A	N/A	N/A	1,010	834.9	N/A	N/A	N/A	N/A
820	Roosevelt Drive	22.11	1S	--	50	Yes	680	834.6	834.2	0.3	-6.3	-9.0	910	835.2	834.8	0.4	-5.6	-8.3	1,010	835.5	835.1	0.4	-5.4	-8.1
825	Private Bridge	22.17	1S	--	N/A	N/A	680	837.9	836.0	0.7	-4.5	-6.0	910	839.0	836.5	1.3	-3.6	-5.1	1,010	839.3	836.8	1.6	-3.2	-4.7
830	Chicago, Milwaukee, St. Paul, and Pacific Railroad	22.21	1S	--	100	Yes	680	838.1	837.9	0.0	-2.4	-3.1	910	839.2	839.0	0.0	-1.4	-2.1	1,010	839.7	839.3	0.0	-0.6	-1.3
835	Chicago, Milwaukee, St. Paul, and Pacific Railroad	22.28	1S	--	100	Yes	680	839.2	838.5	0.5	-3.1	-3.7	910	840.2	839.4	0.5	-2.1	-2.7	1,010	841.0	840.5	0.3	-1.2	-1.8
840	Private Bridge	22.72	1S	--	N/A	N/A	680	839.9	839.6	0.3	-0.5	-3.4	910	841.0	840.6	0.3	0.6	-2.3	1,010	841.4	841.3	0.0	1.2	-1.7
845	County Line Road (CTH Q)	23.47	1S	--	50	Yes	680	840.8	840.6	0.2	-1.6	-3.9	910	842.0	841.5	0.5	-0.6	-2.9	1,010	842.4	841.8	0.3	0.0	-2.3
850	Private Bridge	24.32	1S	--	N/A	N/A	680	841.4	841.1	0.3	-0.3	-0.7	910	842.1	842.1	0.0	0.8	0.4	1,010	842.6	842.4	0.2	1.2	0.8
855	STH 41 and 45	24.84	1S	--	100	Yes	680	842.2	841.6	0.6	-3.1	-3.4	910	843.4	842.4	1.0	-2.0	-2.3	1,010	844.0	842.7	1.3	-1.4	-1.7
860	Lilac Lane	25.27	1S	--	10	Yes	680	844.2	842.7	1.4	-0.6	-2.8	910	845.0	843.5	1.5	0.2	-2.0	1,010	845.3	844.1	1.2	1.5	-0.7
865	Mequon Road	25.93	1S	--	50	Yes	680	845.4	844.9	0.5	-5.2	-5.5	910	846.1	845.5	0.6	-4.6	-4.9	1,010	846.4	845.8	0.6	-4.4	-4.7
870	River Lane	25.98	1S	--	50	No	680	846.1	845.4	0.7	-2.5	-2.7	910	847.8	846.1	1.7	0.1	-0.1	1,010	848.1	846.4	1.7	0.4	0.2
875	Chicago, Milwaukee, St. Paul, and Pacific Railroad	26.92	1S	1906	100	Yes	680	848.4	847.1	0.7	-4.8	-6.0	910	849.2	847.6	1.0	-4.2	-5.4	1,010	849.6	847.8	1.0	-4.0	-5.2
880	Freistadt Road	27.17	1S	--	50	No	305	848.7	848.4	0.3	-1.1	-1.3	485	849.8	849.3	0.5	0.1	-0.1	570	850.0	849.6	0.4	0.4	0.2
885	STH 145	27.29	1S	--	50	Yes	305	848.7	848.7	0.0	-4.9	-5.1	485	849.9	849.8	0.1	-3.8	-4.0	570	850.2	850.1	0.1	-3.6	-3.8
890	Chicago and Northwestern Railroad	27.91	1S	--	100	Yes	305	849.0	848.9	0.1	-6.6	-7.4	485	850.0	850.0	0.0	-5.5	-6.3	570	850.4	850.3	0.1	-5.3	-6.1
894	Private Bridge	28.66	1I	--	N/A	N/A	185	N/A	N/A	N/A	N/A	N/A	275	N/A	N/A	N/A	N/A	N/A	315	N/A	N/A	N/A	N/A	N/A
895	Pleasant View Drive	28.70	1S	--	50	Yes	185	850.8	850.7	0.1	-4.7	-5.4	275	851.6	851.4	0.2	-3.9	-4.6	315	852.0	851.8	0.2	-3.7	-4.4
900	E. Lovers Lane Road	28.95	1S	--	10	Yes	185	851.2	851.0	0.1	-3.2	-3.4	275	852.2	851.9	0.3	-2.5	-2.7	315	852.8	852.2	0.6	-1.9	-2.1

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-3

HYDROLOGIC-HYDRAULIC SUMMARY—HONEY CREEK

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
947	Natural Channel Drop	0.04	3S	N/A	N/A	N/A	2,460	646.8	646.6	N/A	N/A	N/A	3,190	648.5	648.2	N/A	N/A	N/A	3,490	649.1	648.9	N/A	N/A	N/A
948	Natural Channel Drop	0.05	3S	N/A	N/A	N/A	2,460	647.4	646.8	N/A	N/A	N/A	3,190	648.7	648.5	N/A	N/A	N/A	3,490	649.3	649.1	N/A	N/A	N/A
949	Natural Channel Drop	0.06	3S	N/A	N/A	N/A	2,460	647.9	647.4	N/A	N/A	N/A	3,190	649.0	648.7	N/A	N/A	N/A	3,490	649.6	649.3	N/A	N/A	N/A
950	Honey Creek Parkway	0.17	1S	--	10	No	2,460	653.1	652.1	0.0	1.7	1.1	3,190	653.6	653.0	0.0	2.2	1.6	3,490	653.9	653.3	0.0	2.4	1.8
955	W. Portland Avenue	0.50	1S	--	10	Yes	2,460	666.6	663.1	2.6	-5.6	-7.5	3,190	668.6	664.2	3.3	-4.4	-6.3	3,490	670.1	664.6	4.6	-1.6	-3.5
960	Honey Creek Parkway	0.61	1S	--	10	Yes	2,460	670.6	666.6	2.8	-3.4	-3.6	3,190	672.8	667.6	3.5	0.3	0.1	3,490	673.3	669.9	2.7	1.2	1.0
965	W. Wisconsin Avenue	0.91	1S	--	10	No	2,070	681.1	676.9	4.0	0.8	0.8	2,480	681.6	678.3	3.0	1.4	1.4	2,620	681.8	678.8	2.7	1.6	1.6
970	Honey Creek Parkway	1.10	1S	--	10	Yes	2,070	681.1	681.1	0.0	-9.7	-9.7	2,480	681.6	681.6	0.0	-9.4	-9.4	2,620	681.9	681.9	0.0	-9.3	-9.3
975	W. Bluemound Road (USH 18)	1.22	1S	--	50	Yes	2,070	683.5	681.1	2.4	-11.1	-11.1	2,480	684.8	681.6	3.2	-10.1	-10.1	2,620	685.3	681.9	3.4	-9.8	-9.8
980	Honey Creek Parkway	1.39	1S	--	10	Yes	2,070	683.8	683.7	0.0	-7.4	-8.0	2,480	685.1	685.0	0.0	-6.3	-6.9	2,620	685.5	685.4	0.0	-6.0	-6.6
982	Drop Structure	1.44	3S	--	N/A	N/A	2,070	683.2	683.4	N/A	N/A	N/A	2,480	684.4	684.7	N/A	N/A	N/A	2,620	684.9	685.2	N/A	N/A	N/A
983	Drop Structure	1.52	3S	--	N/A	N/A	2,070	685.5	684.7	N/A	N/A	N/A	2,480	686.1	685.7	N/A	N/A	N/A	2,620	686.5	686.0	N/A	N/A	N/A
984	Drop Structure	1.81	3S	--	N/A	N/A	2,070	690.5	689.3	N/A	N/A	N/A	2,480	691.1	689.9	N/A	N/A	N/A	2,620	691.3	690.0	N/A	N/A	N/A
985	S. 84th Street	1.83	1S	--	50	Yes	2,070	691.9	690.5	0.0	-7.7	-7.7	2,480	690.9	691.1	0.0	-7.6	-7.6	2,620	692.2	691.3	0.0	-7.3	-7.3
990	S. 84th Street Outlet	1.99	4S	--	N/A	N/A	2,070	N/A	693.5	N/A	N/A	N/A	2,480	N/A	694.0	N/A	N/A	N/A	2,620	N/A	694.2	N/A	N/A	N/A
--	East-West Freeway (I 94)	2.04	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	Chicago, Milwaukee, St. Paul, and Pacific Railroad	2.42	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Greenfield Avenue	3.10	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Orchard Street	3.21	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Lapham Avenue	3.34	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. National Avenue	3.52	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Burnham Avenue	3.55	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Rogers Street	3.68	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Becher Street	3.81	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Grant Street	3.98	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Lincoln Avenue	4.06	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Hayes Avenue	4.18	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
--	W. Arthur Avenue	4.31	N/A	--	N/A	N/A	2,070	N/A	N/A	N/A	N/A	N/A	2,480	N/A	N/A	N/A	N/A	N/A	2,620	N/A	N/A	N/A	N/A	N/A
1080	W. Arthur Avenue Inlet	4.32	4S	--	N/A	N/A	1,620	723.1	N/A	N/A	N/A	N/A	2,210	725.2	N/A	N/A	N/A	N/A	2,540	726.2	N/A	N/A	N/A	N/A
1085	Park Pedestrian Bridge	4.57	1I	--	N/A	N/A	1,620	N/A	N/A	N/A	N/A	N/A	2,210	N/A	N/A	N/A	N/A	N/A	2,540	N/A	N/A	N/A	N/A	N/A
1090	W. Beloit Road	4.68	1S	--	50	Yes	1,620	726.3	725.9	0.3	-8.3	-9.5	2,210	727.7	727.0	0.5	-7.0	-8.2	2,540	728.5	727.9	0.5	-6.2	-7.4
1095	S. 76th Street	5.11	1S	--	50	Yes	1,620	728.3	728.1	0.1	-6.5	-7.2	2,210	729.4	729.3	0.0	-5.4	-6.1	2,540	730.6	729.9	0.5	-4.2	-4.9
1100	W. Oklahoma Avenue	5.27	1S	--	50	Yes	1,620	729.4	729.0	0.3	-5.5	-7.2	2,210	730.4	730.2	0.0	-4.4	-6.1	2,540	731.4	731.0	0.3	-3.5	-5.2
1105	S. 72nd Street	5.51	1S	--	10	Yes	1,620	731.5	730.6	0.4	-3.4	-3.4	2,210	734.7	731.8	2.4	-0.3	-0.3	2,540	735.4	732.4	2.6	0.5	0.5
1112	Drop Structure	5.69	3S	--	N/A	N/A	1,620	732.5	732.1	N/A	N/A	N/A	2,210	734.8	734.7	N/A	N/A	N/A	2,540	735.7	735.6	N/A	N/A	N/A
1113	Small Dam	5.94	2I	--	N/A	N/A	1,620	N/A	N/A	N/A	N/A	N/A	2,210	N/A	N/A	N/A	N/A	N/A	2,540	N/A	N/A	N/A	N/A	N/A
1114	Drop Structure	5.94	3S	--	N/A	N/A	1,620	737.2	735.2	N/A	N/A	N/A	2,210	738.2	736.2	N/A	N/A	N/A	2,540	738.8	736.6	N/A	N/A	N/A
1115	W. Morgan Avenue	5.96	1S	--	50	Yes	1,620	738.1	737.2	0.0	-4.5	-5.0	2,210	739.9	738.2	0.0	-2.9	-3.4	2,540	740.6	738.8	0.0	-2.3	-2.8
1120	S. 68th Street	6.18	1S	--	50	Yes	1,620	741.2	739.9	0.8	-7.6	-7.8	2,210	742.4	740.8	1.3	-7.0	-7.2	2,540	743.1	741.3	1.6	-6.7	-6.9
1125	W. Howard Avenue	6.54	1S	1972	50	Yes	835	744.4	744.4	0.0	-7.0	-7.9	1,290	745.8	745.8	0.0	-5.6	-6.5	1,520	746.4	746.4	0.0	-5.0	-5.9
1130	W. Forest Home Avenue	6.56	1S	--	50	Yes	835	744.3	744.4	0.0	-8.2	-8.4	1,290	745.7	745.8	0.0	-6.8	-7.0	1,520	746.3	746.4	0.0	-6.1	-6.3
1135	S. 60th Street	7.06	1S	--	50	Yes	835	747.6	747.0	0.3	-9.6	-10.2	1,290	749.5	748.8	0.3	-7.7	-8.3	1,520	750.6	749.6	0.4	-6.8	-7.4
1140	W. Coldspring Road	7.19	1S	--	10	Yes	835	749.2	748.5	0.2	-7.5	-7.5	1,290	750.8	750.1	0.1	-5.8	-5.8	1,520	751.6	750.8	0.5	-5.0	-5.0
1145	Airport Freeway (IH 894)	7.53	1S	--	100	Yes	835	751.0	750.6	0.0	-17.1	-17.1	1,290	752.8	752.4	0.0	-15.5	15.5	1,520	753.6	753.2	0.0	-14.7	-14.7

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-4

HYDROLOGIC-HYDRAULIC SUMMARY—UNDERWOOD CREEK

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1190	Drop Structure	0.24	3S	--	N/A	N/A	2,900	677.5	677.3	N/A	N/A	N/A	4,940	680.2	680.0	N/A	N/A	N/A	6,100	681.1	681.0	N/A	N/A	N/A
1195	Drop Structure	0.63	3S	--	N/A	N/A	2,900	680.9	680.7	N/A	N/A	N/A	4,940	682.7	683.4	N/A	N/A	N/A	6,100	684.0	684.4	N/A	N/A	N/A
1196	Drop Structure	0.67	3S	--	N/A	N/A	2,900	685.4	682.4	N/A	N/A	N/A	4,940	686.9	684.3	N/A	N/A	N/A	6,100	687.8	684.9	N/A	N/A	N/A
1200	Zoo Freeway (USH 45)	0.75	1I	--	100	Yes	2,900	N/A	N/A	N/A	N/A	N/A	4,940	N/A	N/A	N/A	N/A	N/A	6,100	N/A	N/A	N/A	N/A	N/A
1201	Drop Structure	0.80	3S	--	N/A	N/A	2,900	692.9	687.7	N/A	N/A	N/A	4,940	696.7	690.0	N/A	N/A	N/A	6,100	698.4	691.0	N/A	N/A	N/A
1202	Chicago, Milwaukee, St. Paul, and Pacific Railroad	0.81	1S	1947	100	No	2,900	695.0	692.9	0.0	-4.8	-5.2	4,940	699.6	696.7	0.0	1.4	1.0	6,100	700.8	698.4	0.0	2.6	2.2
1205	North Mayfair Road (STH 100)	1.27	1S	1972	50	Yes	2,900	696.7	695.9	0.7	-25.0	-25.8	4,940	700.2	699.7	0.5	-21.7	-21.7	6,100	701.4	701.0	0.4	-20.4	-20.4
1210	Drop Structure (Chicago and Northwestern Railroad)	1.46	3S	--	N/A	N/A	2,900	704.5	698.7	N/A	N/A	N/A	4,940	708.9	701.2	N/A	N/A	N/A	6,100	711.0	702.3	N/A	N/A	N/A
1215	W. Watertown Plank Road	1.50	1I	1972	50	Yes	2,900	N/A	N/A	N/A	N/A	N/A	4,940	N/A	N/A	N/A	N/A	N/A	6,100	N/A	N/A	N/A	N/A	N/A
1216	Drop Structure	1.53	3S	--	N/A	N/A	2,310	705.3	704.5	N/A	N/A	N/A	3,800	709.5	709.0	N/A	N/A	N/A	4,620	711.8	711.2	N/A	N/A	N/A
1217	Drop Structure	1.63	3S	--	N/A	N/A	2,310	706.4	705.9	N/A	N/A	N/A	3,800	709.9	709.7	N/A	N/A	N/A	4,620	711.8	711.8	N/A	N/A	N/A
1218	Drop Structure	1.69	3S	--	N/A	N/A	2,310	707.7	707.3	N/A	N/A	N/A	3,800	710.5	710.3	N/A	N/A	N/A	4,620	711.9	711.8	N/A	N/A	N/A
1220	N. 115th Street	1.87	1S	1972	10	Yes	2,310	711.1	710.0	1.0	-11.7	-11.7	3,800	717.0	711.8	5.1	-6.1	-6.1	4,620	720.6	712.4	8.0	-2.7	-2.7
1230	United Parcel Service	2.57	1S	--	N/A	N/A	810	721.2	720.3	0.0	-1.9	-3.6	1,510	723.1	722.2	0.0	0.2	-1.5	1,940	723.5	722.8	0.0	0.7	-1.0
1234	Private Bridge	2.63	1S	1973	N/A	N/A	810	723.5	722.6	0.0	1.0	0.6	1,510	724.1	723.6	0.0	1.7	1.3	1,940	724.5	724.1	0.0	2.1	1.7
1240	Private Bridge	2.67	1S	1973	N/A	N/A	810	723.5	723.5	0.0	0.6	-0.5	1,510	724.3	724.1	0.0	1.4	0.3	1,940	724.6	724.5	0.0	1.8	0.7
1245	Private Bridge	2.69	1S	1973	N/A	N/A	810	724.2	723.5	0.7	1.1	0.1	1,510	725.6	724.3	1.0	1.6	0.6	1,940	725.8	724.6	1.1	1.8	0.8
1250	Private Bridge	2.73	1S	--	N/A	N/A	810	725.8	724.2	0.4	0.6	0.0	1,510	726.4	725.6	0.0	1.3	0.7	1,940	726.6	725.8	0.0	1.6	1.0
1255	Private Bridge	2.83	1S	--	N/A	N/A	810	728.2	725.8	2.4	0.9	-0.3	1,510	729.0	726.6	2.3	1.7	0.5	1,940	729.3	727.1	2.0	1.9	0.7
1260	Chicago, Milwaukee, St. Paul, and Pacific Railroad	3.10	1S	--	100	Yes	810	732.3	730.3	1.8	-7.1	-7.1	1,510	734.2	732.1	1.7	-5.3	-5.3	1,940	735.8	733.0	2.0	-4.0	-4.0
1265	Private Bridge	3.12	1S	--	N/A	N/A	810	733.7	732.3	0.0	1.6	-3.4	1,510	735.0	734.2	0.0	2.6	-2.4	1,940	736.0	735.8	0.0	4.2	-0.8
1270	Wall Street	3.25	1S	--	10	No	810	735.3	735.0	0.0	0.5	-0.8	1,510	737.5	736.2	0.6	2.2	0.9	1,940	737.7	736.9	0.3	2.3	1.0
1271	Elm Grove Shopping Center Outlet	3.31	4S	--	N/A	N/A	810	N/A	737.1	N/A	N/A	N/A	1,510	N/A	737.3	N/A	N/A	N/A	1,940	N/A	737.4	N/A	N/A	N/A
1271A	Elm Grove Shopping Center Inlet	3.41	4S	--	N/A	N/A	810	740.5	N/A	N/A	N/A	N/A	1,510	742.7	N/A	N/A	N/A	N/A	1,940	742.8	N/A	N/A	N/A	N/A
1275	Watertown Plank Road	3.43	1S	--	50	No	810	741.4	740.5	0.4	0.1	0.1	1,510	743.3	742.7	0.0	1.2	1.2	1,940	743.4	742.8	0.0	1.5	1.5
1276	Private Bridge	3.45	1S	--	N/A	N/A	810	742.4	741.4	0.0	2.5	2.3	1,510	743.9	743.3	0.0	3.7	3.5	1,940	744.2	743.4	0.0	4.1	3.9
1280	Private Bridge	3.50	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1285	Private Bridge	3.53	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1290	Chicago, Milwaukee, St. Paul, and Pacific Railroad	3.55	1S	1910	100	No	810	743.8	743.5	0.3	-1.8	-5.0	1,510	745.3	744.7	0.6	-0.5	-3.7	1,940	745.7	745.1	0.6	0.2	-3.0
1295	W. Juneau Boulevard	3.67	1S	--	10	No	810	744.0	744.0	0.0	1.7	1.1	1,510	745.4	745.3	0.1	3.1	2.5	1,940	745.8	745.7	0.1	3.5	2.9
1300	Village Hall Bridge	3.76	1S	--	10	No	810	744.3	744.0	0.3	0.8	0.8	1,510	745.5	745.4	0.1	2.0	2.0	1,940	745.9	745.8	0.1	2.5	2.5
1305	W. Marcella Avenue	4.48	1S	--	10	No	810	748.5	747.5	0.7	0.7	0.5	1,510	748.8	748.6	0.0	1.4	1.2	1,940	749.3	748.9	0.1	1.9	1.7
1310	W. North Avenue	4.82	1S	--	50	No	810	751.5	749.6	1.8	0.7	-0.2	1,510	752.0	751.0	0.9	1.3	0.4	1,940	752.3	751.7	0.6	1.5	0.6
1315	Clear Water Road	5.59	1S	--	10	No	810	756.2	755.2	0.7	0.5	-0.4	1,510	757.5	756.6	0.2	0.8	-0.1	1,940	757.9	756.8	0.6	1.0	0.1
1316	Private Bridge	5.87	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1320	Santa Maria Court	5.99	1S	--	10	No	810	772.2	765.6	5.0	0.6	0.4	1,510	773.6	766.4	6.0	1.4	1.2	1,940	774.3	766.9	6.0	1.7	1.5
1325	Woodbridge Road	6.08	1S	--	10	Yes	810	787.1	778.4	6.4	-1.9	-3.2	1,510	788.6	779.5	6.9	1.8	0.5	1,940	789.2	780.0	7.0	2.3	1.0
1330	Indian Creek Parkway	6.20	1S	--	10	No	810	796.5	791.2	4.0	0.4	0.4	1,510	798.3	793.2	3.0	2.2	2.2	1,940	798.9	794.0	3.0	2.7	2.7
1335	Chicago, Milwaukee, St. Paul, and Pacific Railroad	6.32	1S	--	100	No	810	804.3	797.9	6.0	-14.1	-16.6	1,510	815.7	799.4	16.0	-1.6	-4.1	1,940	817.4	799.6	17.5	1.3	-1.2
1336	Private Bridge	6.37	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1337A	Private Bridge	6.41	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1337	Private Bridge	6.48	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1338	Private Bridge	6.50	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1339	Private Bridge	6.51	1S	--	N/A	N/A	810	808.1	806.7	0.0	1.6	0.8	1,510	815.6	815.6	0.0	8.3	7.5	1,940	817.3	817.4	0.0	10.0	9.2
1340	Private Bridge	6.60	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1345	Private Bridge	6.64	1S	--	N/A	N/A	810	817.3	816.0	0.0	1.3	0.7	1,510	818.6	817.8	0.0	1.8	1.2	1,940	819.4	818.9	0.0	2.0	1.4
1346	Private Bridge	6.65	1S	--	N/A	N/A	810	818.0	817.3	0.0	2.4	1.1	1,510	819.1	818.6	0.0	3.0	1.7	1,940	819.8	819.4	0.0	3.3	2.0
1350	Pilgrim Parkway	6.68	1S	--	50	No	810	821.0	819.5	0.0	3.9	-1.6	1,510	821.1	820.1	0.0	3.9	-1.6	1,940	821.2	820.5	0.0	4.1	-1.4
1351	Pedestrian Bridge	6.69	1I	--	N/A	N/A	810	N/A	N/A	N/A	N/A	N/A	1,510	N/A	N/A	N/A	N/A	N/A	1,940	N/A	N/A	N/A	N/A	N/A
1353	Park Bridge	7.24	1I	--	N/A	N/A	75	N/A	N/A	N/A	N/A	N/A	140	N/A	N/A	N/A	N/A	N/A	180	N/A	N/A	N/A	N/A	N/A

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

[e] *Bluemound Road's approach road is overtopped during a 50-year recurrence interval flood on Underwood Creek.*

Source: SEWRPC.

Table E-5

HYDROLOGIC-HYDRAULIC SUMMARY—SOUTH BRANCH OF UNDERWOOD CREEK

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1800	W. Bluemound Road	0.05	1S	1962	50	No[e]	1,770	715.5	715.5	0.0	- 6.7	- 8.4	2,460	718.7	718.8	0.0	- 3.4	- 5.1	2,760	722.0	721.8	0.0	- 0.3	- 2.0
1805	Chicago, Milwaukee, St. Paul, and Pacific Railroad	0.15	1S	--	100	Yes	1,770	716.9	716.7	0.0	- 12.6	- 13.0	2,460	719.0	718.9	0.0	- 10.5	- 10.9	2,760	722.1	722.0	0.1	- 7.5	- 7.9
1810	East-West Freeway (I 94)	0.57	1S	--	100	Yes	1,770	719.7	719.2	0.4	- 29.0	- 29.0	2,460	721.3	720.5	0.6	- 27.3	- 27.3	2,760	723.0	722.6	0.4	- 25.5	- 25.5
1815	N. 120th Street Outfall	1.08	4S	--	N/A	N/A	N/A	N/A	722.1	N/A	N/A	N/A	N/A	N/A	723.4	N/A	N/A	N/A	N/A	N/A	724.4	N/A	N/A	N/A

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

[e] *W. Bluemound Road approach road is overtopped during a 50-year recurrence interval flood on Underwood Creek.*

Source: SEWRPC.

Table E-6

HYDROLOGIC-HYDRAULIC SUMMARY—DOUSMAN DITCH

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1355	Chicago, Milwaukee, St. Paul, and Pacific Railroad	0.03	1S	1910	100	Yes	595	823.4	823.2	0.2	- 7.2	- 7.6	1,050	824.9	824.5	0.4	- 5.9	- 6.3	1,310	826.8	825.4	1.4	- 4.0	- 4.4
1360	North Avenue (CTH M)	0.06	1S	--	50	No	595	824.6	823.4	1.0	- 0.6	- 1.7	1,050	825.9	824.9	0.8	1.1	0.0	1,310	826.9	826.8	0.0	2.1	1.0
1365	Pedestrian Bridge	0.20	1I	--	N/A	N/A	595	N/A	N/A	N/A	N/A	N/A	1,050	N/A	N/A	N/A	N/A	N/A	1,310	N/A	N/A	N/A	N/A	N/A
1370	Gebhardt Road	0.63	1S	--	10	Yes	595	826.6	826.5	0.0	- 2.3	- 4.4	1,050	828.8	827.9	0.8	0.2	- 1.9	1,310	829.2	828.8	0.3	0.3	- 1.8

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-7

HYDROLOGIC-HYDRAULIC SUMMARY—LITTLE MENOMONEE RIVER

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1400	N. Lovers Lane Road (STH 100)	0.09	1S	1968	50	Yes	1,150	701.5	701.4	0.1	-7.1	-8.7	1,660	703.1	703.1	0.0	-5.5	-7.1	1,900	703.9	703.8	0.0	-4.7	-6.3
1405	Pedestrian Bridge	0.52	1I	N/A	N/A	N/A	1,150	N/A	N/A	N/A	N/A	N/A	1,660	N/A	N/A	N/A	N/A	N/A	1,900	N/A	N/A	N/A	N/A	N/A
1410	W. Silver Spring Drive	1.11	1S	--	50	Yes	1,150	702.9	702.8	0.0	-4.1	-6.2	1,660	703.9	703.9	0.0	-3.0	-5.1	1,900	704.6	704.5	0.0	-2.4	-4.5
1415	Chicago and Northwestern Railroad	1.45	1S	1910	100	Yes	1,150	704.7	704.0	0.6	-25.0	-25.0	1,660	705.6	704.8	0.7	-24.3	-24.3	1,900	706.4	705.1	1.2	-23.9	-23.9
1420	W. Appleton Avenue	1.57	1S	1967	50	Yes	1,150	705.1	704.8	0.3	-4.2	-4.8	1,660	706.0	705.9	0.1	-3.3	-3.9	1,900	706.6	706.4	0.2	-2.8	-3.4
1425	W. Mill Road	2.41	1S	--	50	No	1,150	710.6	710.5	0.0	1.3	-0.9	1,660	711.2	711.1	0.0	1.8	-0.4	1,900	711.6	711.5	0.0	2.1	-0.1
1430	Fond du Lac Freeway (STH 145)	2.58	1S	--	100	Yes	1,150	711.0	710.9	0.0	-15.2	-16.9	1,660	711.7	711.6	0.0	-14.6	-16.3	1,900	712.0	711.9	0.0	-14.3	-16.0
1435	W. Leon Terrace	2.62	1S	1965	10	No	1,150	711.1	711.0	0.0	1.2	0.8	1,660	711.8	711.7	0.0	1.9	1.5	1,900	712.1	712.0	0.0	2.2	1.8
1437	Park Bridge	3.33	1I	--	N/A	N/A	605	N/A	N/A	N/A	N/A	N/A	870	N/A	N/A	N/A	N/A	N/A	995	N/A	N/A	N/A	N/A	N/A
1440	W. Good Hope Road (CTH PP)	3.62	1S	--	50	Yes	605	712.0	711.9	0.0	-3.1	-3.8	870	712.8	712.5	0.3	-2.5	-3.2	995	713.4	712.8	0.6	-2.2	-2.9
1445	N. Granville Road (CTH F)	3.70	1S	--	10	Yes	605	712.3	712.2	0.0	-1.9	-4.9	870	713.1	713.0	0.1	-1.2	-4.2	995	713.7	713.4	0.3	-0.8	-3.8
1450	W. Calumet Road	4.13	1S	--	10	Yes	605	714.5	714.3	0.2	-1.4	-4.9	870	715.1	714.8	0.3	-0.9	-4.4	995	715.4	715.0	0.4	-0.8	-4.3
1445	W. Bradley Road	4.65	1S	--	50	Yes	350	716.3	716.3	0.0	-2.1	-4.5	525	716.8	716.7	0.1	-1.7	-4.1	605	717.1	716.8	0.3	-1.5	-3.9
1456	Chicago, Milwaukee, St. Paul, and Pacific Railroad	4.73	1S	--	100	Yes	350	716.4	716.4	0.0	-6.6	-8.9	525	717.0	716.9	0.1	-6.1	-8.4	605	717.2	717.1	0.1	-5.9	-8.2
1460	Private Bridge	5.62	1I	--	N/A	N/A	350	N/A	N/A	N/A	N/A	N/A	525	N/A	N/A	N/A	N/A	N/A	605	N/A	N/A	N/A	N/A	N/A
1465	Chicago and Northwestern Railroad	5.84	1S	1902	100	Yes	350	718.6	718.5	0.0	-9.8	-10.0	525	719.2	719.1	0.0	-9.3	-9.5	605	719.4	719.3	0.1	-9.1	-9.3
1470	W. Brown Deer Road	5.88	1S	--	50	Yes	350	718.7	718.6	0.1	-2.9	-3.0	525	719.6	719.2	0.4	-2.1	-2.2	605	720.0	719.5	0.4	-1.7	-1.8
1475	Park Bridge	6.52	1I	--	N/A	N/A	350	N/A	N/A	N/A	N/A	N/A	525	N/A	N/A	N/A	N/A	N/A	605	N/A	N/A	N/A	N/A	N/A
1480	Park Bridge	6.80	1I	--	N/A	N/A	350	N/A	N/A	N/A	N/A	N/A	525	N/A	N/A	N/A	N/A	N/A	605	N/A	N/A	N/A	N/A	N/A
1485	W. County Line Road	6.91	1S	--	50	No	330	719.1	718.7	0.4	0.1	-1.1	500	719.7	719.7	0.0	0.7	-0.5	580	720.1	720.0	0.1	1.1	-0.1
1490	Private Bridge	7.33	1I	--	N/A	N/A	330	N/A	N/A	N/A	N/A	N/A	500	N/A	N/A	N/A	N/A	N/A	580	N/A	N/A	N/A	N/A	N/A
1495	Private Bridge	7.47	1I	--	N/A	N/A	330	N/A	N/A	N/A	N/A	N/A	500	N/A	N/A	N/A	N/A	N/A	580	N/A	N/A	N/A	N/A	N/A
1497	Private Bridge	7.78	1I	--	N/A	N/A	260	N/A	N/A	N/A	N/A	N/A	400	N/A	N/A	N/A	N/A	N/A	465	N/A	N/A	N/A	N/A	N/A
1500	Donges Bay Road	7.97	1S	--	50	Yes	260	723.4	722.8	0.6	-4.2	-5.2	400	724.3	723.4	0.9	-3.6	-4.6	465	724.7	723.8	0.9	-3.3	-4.3
1504	Private Bridge	9.02	1I	--	N/A	N/A	125	N/A	N/A	N/A	N/A	N/A	235	N/A	N/A	N/A	N/A	N/A	300	N/A	N/A	N/A	N/A	N/A
1505	Mequon Road (STH 167)	9.12	1S	--	50	Yes	125	725.3	724.4	0.8	-7.3	-8.0	235	726.5	725.2	1.3	-6.4	-7.1	300	727.0	725.6	1.4	-5.9	-6.6
1506	Private Bridge	9.17	1I	--	N/A	N/A	125	N/A	N/A	N/A	N/A	N/A	235	N/A	N/A	N/A	N/A	N/A	300	N/A	N/A	N/A	N/A	N/A
1510	Freistadt Road	10.18	1S	--	50	Yes	125	729.5	728.9	0.2	-3.7	-4.4	235	730.4	729.9	0.3	-2.9	-3.6	300	730.9	730.1	0.5	-2.4	-3.1

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-8

HYDROLOGIC-HYDRAULIC SUMMARY—LITTLE MENOMONEE CREEK

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1700	Private Bridge	0.29	1I	--	N/A	N/A	145	N/A	N/A	N/A	N/A	N/A	240	N/A	N/A	N/A	N/A	N/A	290	N/A	N/A	N/A	N/A	N/A
1705	Private Bridge	0.58	1I	--	N/A	N/A	145	N/A	N/A	N/A	N/A	N/A	240	N/A	N/A	N/A	N/A	N/A	290	N/A	N/A	N/A	N/A	N/A
1710	Granville Road	0.82	1S	--	50	Yes	145	754.3	753.1	0.5	-6.3	-7.3	240	754.5	753.3	0.5	-5.7	-6.7	290	754.7	753.4	0.6	-5.4	-6.4
1712	Private Bridge	0.84	1I	--	N/A	N/A	145	N/A	N/A	N/A	N/A	N/A	240	N/A	N/A	N/A	N/A	N/A	290	N/A	N/A	N/A	N/A	N/A
1714	Private Bridge	0.91	1I	--	N/A	N/A	145	N/A	N/A	N/A	N/A	N/A	240	N/A	N/A	N/A	N/A	N/A	290	N/A	N/A	N/A	N/A	N/A
1715	Mequon Road (STH 167)	1.03	1S	--	50	Yes	145	767.8	765.9	0.0	-4.7	-5.5	240	768.6	766.5	0.0	-3.9	-4.7	290	769.0	766.5	0.0	-3.6	-4.4
1717	Private Bridge	1.89	1I	--	N/A	N/A	145	N/A	N/A	N/A	N/A	N/A	240	N/A	N/A	N/A	N/A	N/A	290	N/A	N/A	N/A	N/A	N/A
1720	Freistadt Road (CTH F)	2.25	1S	--	50	Yes	145	795.9	795.1	0.7	-4.0	-4.6	240	797.4	795.5	1.9	-2.9	-3.5	290	798.0	795.6	2.3	-2.4	-3.0

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-9

HYDROLOGIC-HYDRAULIC SUMMARY—BUTLER DITCH

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
1600	Private Bridge	0.27	1I	--	N/A	N/A	645	N/A	N/A	N/A	N/A	N/A	1,210	N/A	N/A	N/A	N/A	N/A	1,550	N/A	N/A	N/A	N/A	N/A
1610	Private Bridge	0.86	1I	--	N/A	N/A	645	N/A	N/A	N/A	N/A	N/A	1,210	N/A	N/A	N/A	N/A	N/A	1,550	N/A	N/A	N/A	N/A	N/A
1615	Hampton Road (CTH KK)	1.02	1S	--	50	No	645	749.3	748.3	0.6	- 1.8	- 2.5	1,210	752.1	749.2	2.7	1.0	0.3	1,550	752.5	749.6	2.6	1.3	0.6
1620	Lisbon Road (CTH K)	1.35	1S	--	50	No	645	754.6	753.5	0.8	- 1.6	- 2.5	1,210	756.1	754.2	1.6	0.5	- 0.4	1,550	756.5	754.5	1.7	0.9	0.0
1625	Lilly Road	1.76	1S	--	10	Yes	645	756.6	755.8	0.7	- 0.7	- 1.7	1,210	758.7	756.7	1.9	2.0	1.0	1,550	758.7	757.0	1.6	4.0	3.0

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-10

HYDROLOGIC-HYDRAULIC SUMMARY—LILLY CREEK

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
3110	Appleton Avenue	0.40	1S	1971	50	No	1,110	756.8	755.7	0.0	- 1.8	- 4.2	1,810	759.6	757.3	0.6	0.9	- 1.5	2,160	760.4	758.7	0.4	1.7	- 0.7
3120	Good Hope Road	0.84	1S	--	50	No	1,110	766.7	759.5	7.0	0.3	0.3	1,810	767.9	761.1	6.6	1.5	1.5	2,160	768.2	761.6	6.4	1.8	1.8
3130	Brentwood Drive	1.06	1S	--	10	No	1,110	767.7	766.8	0.9	1.3	1.3	1,810	768.4	768.0	0.4	2.0	2.0	2,160	768.7	768.3	0.4	2.3	2.3
3140	Lilly Road	1.80	1S	--	50	No	445	773.7	772.7	0.8	- 0.8	- 1.3	715	774.2	773.3	0.8	0.2	- 0.3	855	774.3	773.7	0.5	0.3	- 0.2
3150	Mill Road	1.88	1S	--	50	No	445	775.2	773.8	1.4	0.4	0.4	715	775.6	774.3	1.3	0.9	0.9	855	775.8	774.4	1.3	1.0	1.0
3160	Private Bridge	2.02	1I	--	N/A	N/A	445	N/A	N/A	N/A	N/A	N/A	715	N/A	N/A	N/A	N/A	N/A	855	N/A	N/A	N/A	N/A	N/A
3170	Private Bridge	2.11	1S	--	N/A	N/A	445	775.9	775.3	0.1	1.5	1.1	715	776.0	775.9	0.1	2.0	1.6	855	776.2	776.1	0.1	2.2	1.8
3175	Private Bridge	2.20	1S	--	N/A	N/A	445	775.7	775.6	0.1	2.0	2.0	715	776.3	776.2	0.0	2.6	2.6	855	776.5	776.4	0.0	2.9	2.9
3180	Private Bridge	2.27	1I	--	N/A	N/A	445	N/A	N/A	N/A	N/A	N/A	715	N/A	N/A	N/A	N/A	N/A	855	N/A	N/A	N/A	N/A	N/A
3185	Kaul Avenue	2.43	1S	--	10	No	445	775.9	775.9	0.0	2.6	1.3	715	776.5	776.5	0.0	3.2	1.9	855	776.8	776.7	0.0	3.4	2.1
3190	W. Bobolink Avenue	2.48	1S	--	10	No	445	776.1	775.9	0.2	1.2	1.2	715	776.7	776.5	0.2	1.9	1.9	855	777.0	776.8	0.1	2.1	2.1
3193	Private Bridge	2.55	1S	--	N/A	N/A	445	777.0	776.3	0.6	1.0	0.1	715	777.3	777.0	0.2	1.2	0.3	855	777.5	777.2	0.2	1.5	0.6
3195	Chicago and Northwestern Railroad	2.59	1S	1910	100	Yes	445	777.9	777.0	0.0	- 13.9	- 14.7	715	779.4	777.3	1.6	- 13.3	- 14.1	855	780.4	777.5	2.4	- 12.4	- 13.2
3200	Silver Spring Road	2.97	1S	--	50	No	445	779.2	778.0	1.2	0.8	0.8	715	779.8	779.4	0.4	1.4	1.4	855	780.6	780.4	0.2	2.1	2.1

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-11

HYDROLOGIC-HYDRAULIC SUMMARY—NOR-X-WAY CHANNEL

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
3400	Fond du Lac Avenue	0.07	1S	--	50	No	655	753.6	752.3	1.3	-0.9	-1.1	955	754.4	753.2	1.2	0.4	0.2	1,090	754.6	753.6	1.0	0.6	0.4
3405	Entrance Ramp 41945 (USH 41, USH 45)	0.13	1S	--	10	Yes	655	754.3	753.6	0.7	-5.7	-5.7	955	755.9	754.4	1.5	-5.5	-5.5	1,090	756.2	754.6	1.6	-4.9	-4.9
3410	Fond du Lac Freeway (USH 41 and 45)	0.17	1S	--	100	No	655	755.4	754.3	0.0	-2.9	-3.1	955	758.2	755.9	0.0	0.2	0.0	1,090	758.6	756.2	0.0	0.6	0.4
3420	Stanley Drive	0.27	1S	--	10	No	655	756.2	755.4	0.8	0.2	-0.8	955	758.2	758.2	0.0	2.2	1.2	1,090	758.7	758.6	0.1	2.7	1.7
3430	Main Street (STH 74)	0.31	1S	--	50	Yes	655	756.5	756.2	0.0	-3.4	-3.4	955	759.2	758.2	1.0	-0.7	-0.7	1,090	759.8	758.7	1.0	0.2	0.2
3440	Fountain Boulevard	0.45	1S	--	10	Yes	655	757.1	756.5	0.6	-0.9	-0.9	955	759.3	759.3	0.0	1.3	1.3	1,090	759.9	759.8	0.1	1.9	1.9
3450	Warren Street	0.73	1S	--	10	Yes	655	759.4	757.3	1.7	-1.4	-1.4	955	760.1	759.4	0.0	0.4	0.4	1,090	761.4	760.1	0.6	0.6	0.6
3457	Chicago, Milwaukee, St. Paul, and Pacific Railroad	0.82	1S	--	100	Yes	655	761.7	761.5	0.0	-8.4	-8.4	955	763.0	762.7	0.0	-7.4	-7.4	1,090	763.4	763.0	0.0	-7.1	-7.1
3460	USH 145	1.31	1S	--	50	Yes	210	767.3	766.5	0.3	-2.1	-2.1	345	767.9	766.9	0.4	-2.0	-2.0	415	768.3	767.0	0.8	-1.9	-1.9
3465	County Line Road	1.37	1S	--	50	Yes	210	768.5	767.8	0.0	-1.2	-1.2	345	768.9	768.3	0.0	-1.0	-1.0	415	769.0	768.5	0.0	-0.8	-0.8

[a] Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.

[b] A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.

[c] Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.

[d] Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.

Source: SEWRPC.

Table E-12

HYDROLOGIC-HYDRAULIC SUMMARY—WILLOW CREEK

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions						50-Year Recurrence Interval Flood—2000 Land Use Conditions						100-Year Recurrence Interval Flood—2000 Land Use Conditions					
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
3300	Maple Road	0.06	1S	--	50	No	115	842.1	841.6	0.5	0.1	-0.5	160	842.5	842.3	0.2	0.4	-0.2	180	842.7	842.7	0.0	0.7	0.1
3310	Lannon Road	0.65	1S	--	10	Yes	115	842.2	842.1	0.1	-6.9	-7.0	160	842.6	842.5	0.1	-6.5	-6.6	180	842.8	842.7	0.1	-6.3	-6.4
3320	Appleton Avenue (STH 175)	1.15	1S	--	50	Yes	115	856.2	855.0	0.0	-6.6	-6.6	160	856.7	855.4	0.0	-6.2	-6.2	180	856.8	855.5	0.0	-6.0	-6.0

[a] Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.

[b] A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.

[c] Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.

[d] Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.

Source: SEWRPC.

Table E-13

HYDROLOGIC-HYDRAULIC SUMMARY—WEST BRANCH OF THE MENOMONEE RIVER

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions							50-Year Recurrence Interval Flood—2000 Land Use Conditions							100-Year Recurrence Interval Flood—2000 Land Use Conditions						
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
2950	Freistadt Drive	0.33	1S	--	50	Yes	195	851.9	851.0	0.6	- 2.9	- 3.2	285	852.5	851.2	1.1	- 2.4	- 2.7	325	855.4	851.2	3.9	0.8	0.5
2955	Private Bridge	0.39	1S	--	N/A	N/A	195	854.4	853.1	1.1	0.2	- 0.7	285	855.3	853.1	2.0	1.2	0.3	325	855.6	855.4	0.2	1.5	0.6
2960	Private Bridge	0.51	1I	--	N/A	N/A	195	N/A	N/A	N/A	N/A	N/A	285	N/A	N/A	N/A	N/A	N/A	325	N/A	N/A	N/A	N/A	N/A
2965	Maple Road	1.16	1S	--	50	Yes	195	861.8	860.4	0.6	- 4.1	- 4.4	285	862.4	860.7	1.4	- 3.7	- 4.0	325	862.7	860.9	1.4	- 3.6	- 3.9
2970	Chicago, Milwaukee, St. Paul, and Pacific Railroad	1.25	1S	--	100	Yes	45	866.4	864.9	0.7	- 6.8	- 13.1	60	866.9	865.2	1.4	- 6.4	- 12.7	65	867.1	865.2	1.3	- 6.2	- 12.5
2975	Private Bridge	1.63	1S	--	N/A	N/A	45	869.5	868.7	0.6	- 2.6	- 2.6	60	870.0	868.9	0.9	- 2.2	- 2.2	65	870.2	869.0	1.0	- 2.0	- 2.0
2980	Private Bridge	2.05	1S	--	N/A	N/A	45	885.1	882.6	2.0	- 2.0	- 2.0	60	885.6	882.7	2.1	- 1.5	- 1.5	65	885.8	882.8	2.3	- 1.4	- 1.4

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

Table E-14

HYDROLOGIC-HYDRAULIC SUMMARY—NORTH BRANCH OF THE MENOMONEE RIVER

Structure Identification and Selected Characteristics							10-Year Recurrence Interval Flood—2000 Land Use Conditions							50-Year Recurrence Interval Flood—2000 Land Use Conditions							100-Year Recurrence Interval Flood—2000 Land Use Conditions						
Number	Name	River Mile	Structure Type and Hydraulic Significance[a]	Date of Construction or Major Reconstruction	Recommended Design Frequency (years)	Adequate Hydraulic Capacity[b]	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)	Instantaneous Peak Discharge[c] (cfs)	Upstream Stage (feet above msl)	Downstream Stage (feet above msl)	Backwater[d] (feet)	Depth at Low Point in Bridge Approach Road (feet)	Depth on Road at Centerline of Bridge (feet)
2905	Holy Hill Road	0.63	1S	--	10	No	70	852.3	852.1	0.0	0.4	- 2.4	115	852.5	852.2	0.3	0.5	- 2.3	135	852.5	852.2	0.3	0.6	- 2.2
2910	Private Bridge	1.05	1I	--	N/A	N/A	70	N/A	N/A	N/A	N/A	N/A	115	N/A	N/A	N/A	N/A	N/A	135	N/A	N/A	N/A	N/A	N/A
2915	Rockfield Road	1.27	1S	--	50	Yes	70	870.2	869.9	0.0	- 2.4	- 2.9	115	870.6	870.2	0.0	- 2.1	- 2.6	135	870.8	870.3	0.0	- 2.0	- 2.5
2920	Division Road	1.60	1S	--	50	Yes	70	880.3	879.3	0.3	- 4.3	- 4.6	115	880.8	879.8	0.2	- 3.9	- 4.2	135	880.9	879.9	0.1	- 3.7	- 4.0
2925	Chicago and Northwestern Railroad	1.83	1S	--	100	Yes	40	885.0	884.8	0.1	- 4.8	- 4.8	50	885.2	885.0	0.1	- 4.6	- 4.6	55	885.2	885.1	0.0	- 4.5	- 4.5

[a] *Structure codes are as follows: 1—bridge or culvert; 2—dam, sill or weir; 3—drop structure or natural channel drop; 4—fords, outfalls, inlet or outlet structures. Hydraulically significant structures are denoted by an S, hydraulically insignificant structures are denoted by an I.*

[b] *A bridge has an adequate hydraulic capacity if it will remain open during a flood having a recurrence interval equal to or less than the recommended design frequency. A bridge is hydraulically inadequate if the approach road or bridge deck is overtopped by a flood having a recurrence interval equal to or less than the recommended design frequency.*

[c] *Some of the flood discharges appearing in this table are different from the discharges set forth in Table 19 of this volume for identical locations and land use-floodland development conditions. The differences are due to use of existing condition flood discharges in this appendix wherever such discharges exceeded year 2000 planned land use conditions and the desirability of maintaining a continuous, gradual change in discharge along the stream system as opposed to the use of large discrete changes in flood discharge. The discharge differences are not likely to have any significant effect on the corresponding flood stages.*

[d] *Backwater is defined as the maximum increase in stage on the upstream side of a bridge or culvert above that which would occur in the absence of a bridge or culvert. Backwater was determined by extending the flood stage profile on the downstream side of the bridge or culvert upstream through the structure and subtracting the resulting elevation on the upstream side of the structure from the upstream flood stage profile commensurate with the presence of the structure.*

Source: SEWRPC.

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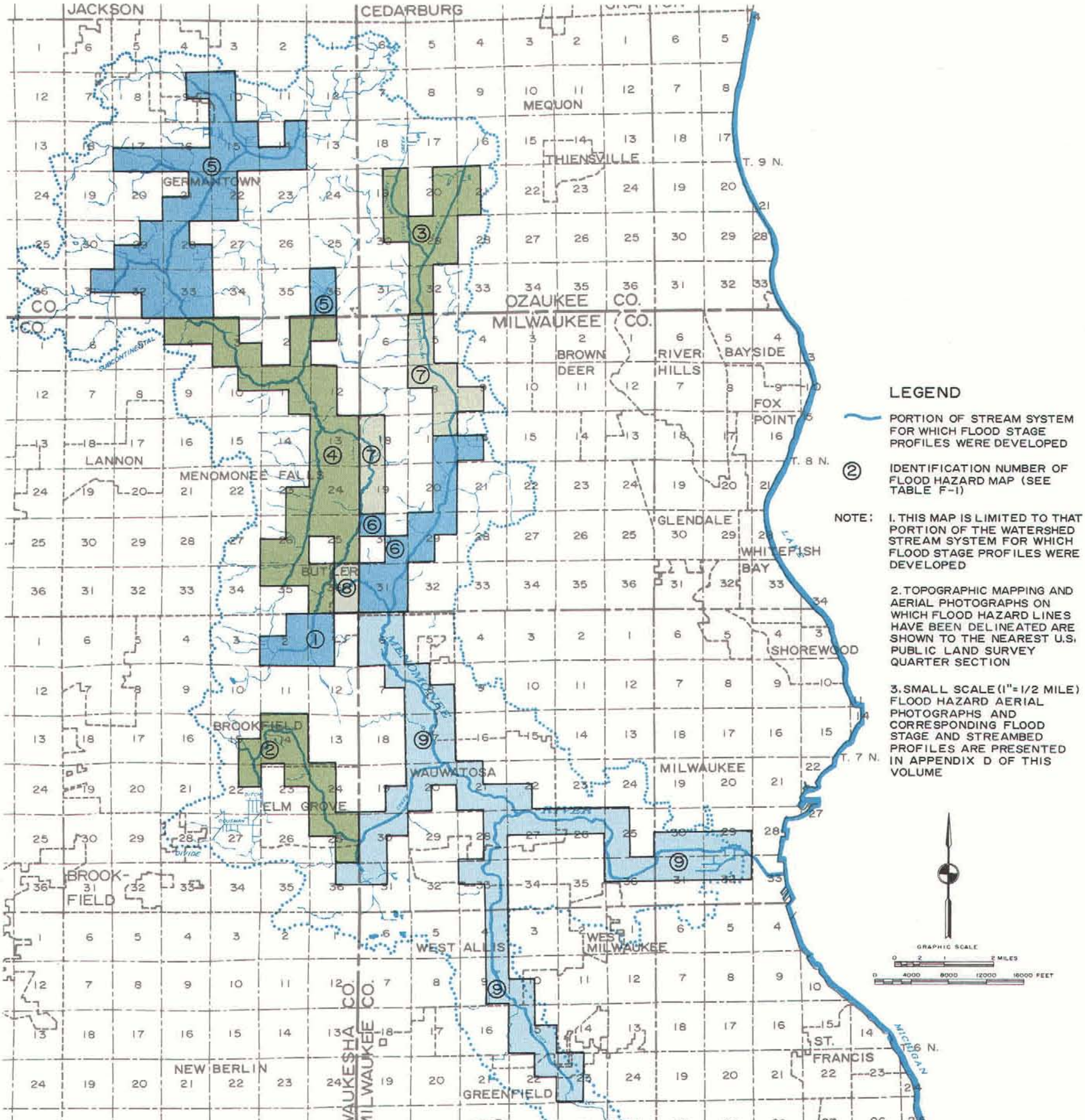
Appendix F

LARGE-SCALE FLOOD HAZARD MAPS AND AERIAL PHOTOGRAPHS

Map F-1

INDEX TO LARGE-SCALE FLOOD HAZARD MAPPING AND TO AERIAL PHOTOGRAPHY IN THE MENOMONEE RIVER WATERSHED: 1976



Source: SEWRPC.

Table F-1

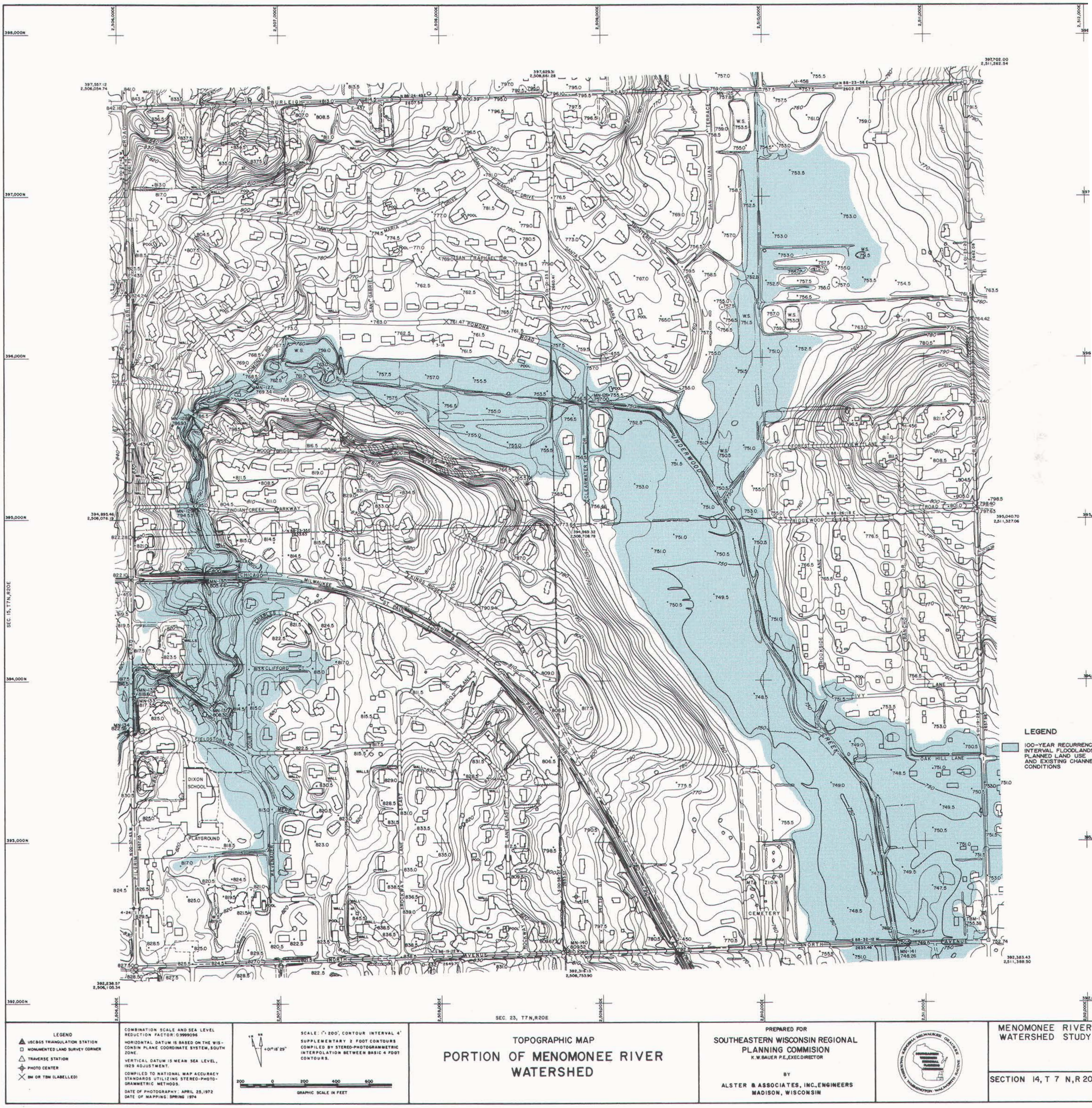
SELECTED INFORMATION PERTAINING TO LARGE SCALE FLOOD HAZARD MAPS AND AERIAL PHOTOGRAPHY IN THE MENOMONEE RIVER WATERSHED

Identification Number on Map F-1	Civil Division		Scale	Contour Interval (feet)	Agency or Community From Which Flood Hazard Mapping Can Be Obtained	Date of Photography or Field Work	Date of Map Preparation
	County	City, Village, or Town					
1	Waukesha	City of Brookfield	1″ = 200′	2	City of Brookfield	May 1975	December 1975
2	Waukesha	City of Brookfield, Village of Elm Grove	1″ = 200′	4-2	SEWRPC	April 1972	Spring 1974
3	Ozaukee	City of Mequon	1″ = 200′	5	City of Mequon	1960	1960
4	Waukesha	Village of Menomonee Falls	1″ = 200′	2	Village of Menomonee Falls	April 1966	1967
5	Washington	Village of Germantown	1″ = 100′	2	Village of Germantown	April and May 1964	1964
6	Milwaukee	City of Milwaukee	1″ = 100′	2	City of Milwaukee	April 1956	April 1958
7	Milwaukee	City of Milwaukee	1″ = 100′	2	City of Milwaukee	April 1962	September 1962
8	Waukesha	Village of Butler	1″ = 100′	2	Wisconsin Department of Transportation, Division of Highways	April 1966	1967
9	Milwaukee, Waukesha	Cities of Wauwatosa, West Allis, Greenfield, Milwaukee, and Brookfield	1″ = 400′	Not Applicable	SEWRPC	May 1975	Not Applicable

Source: SEWRPC.

Map F-2

TYPICAL FLOOD HAZARD MAP OF A PORTION OF THE MENOMONEE RIVER WATERSHED



Source: SEWRPC.

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Appendix G

MODEL RESOLUTION FOR ADOPTION OF THE COMPREHENSIVE PLAN FOR THE MENOMONEE RIVER WATERSHED

WHEREAS, the Southeastern Wisconsin Regional Planning Commission, which was duly created by the Governor of the State of Wisconsin in accordance with Section 66.945(2) of the Wisconsin Statutes on the 8th day of August 1960, upon petition of the Counties of Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha, has the function and duty of making and adopting a master plan for the physical development of the Region; and

WHEREAS, the several county units of government in the Menomonee River watershed, on the 10th day of August 1971, entered into contracts with the Southeastern Wisconsin Regional Planning Commission pursuant to the provisions of Sections 66.30 and 66.945(12) of the Wisconsin Statutes for the development of a comprehensive plan for the Menomonee River watershed leading to recommendations for the development of water-related community facilities in the watershed, including integrated proposals for water pollution abatement, water supply, flood control, land and water use, and park and public open-space reservation, to generally promote the orderly and economical development of the Menomonee River watershed; and

WHEREAS, such plan has been completed and the Southeastern Wisconsin Regional Planning Commission did on the __day of ____________, 197_ approve a resolution adopting the comprehensive plan for the Menomonee River watershed and has recommended such plan to the local units of government within the watershed; and

WHEREAS, such plan contains recommendations for land use development and regulation; environmental corridor land acquisition and preservation; park, parkway, and parkway drive and outdoor recreation land acquisition and development; channel modification and dike, floodwall, and detention reservoir construction; structure floodproofing and removal; bridge replacement or modification; floodway and floodplain regulation; flood insurance and other nonstructural floodland management measures; streamflow recordation; pollution abatement facility construction; land management practices; and water quality monitoring and is, therefore, a desirable and workable water control and water-related community facility plan for the Menomonee River watershed; and

WHEREAS, the aforementioned recommendations, including all studies, data, maps, figures, charts, and tables, are set forth in a published report entitled SEWRPC Planning Report No. 26, <u>A Comprehensive Plan for the Menomonee River Watershed</u>, composed of the following volumes:

Volume 1. <u>Inventory Findings and Forecasts</u>, published in October 1976, and
Volume 2. <u>Alternative Plans and Recommended Plan</u>, published in October 1976; and

WHEREAS, the Commission has transmitted certified copies of its resolution adopting such comprehensive plan for the Menomonee River watershed, together with the aforementioned SEWRPC Planning Report No. 26, to the local units of government; and

WHEREAS, the (Name of Local Governing Body) has supported, participated in the financing of, and generally concurred in the watershed and other regional planning programs undertaken by the Southeastern Wisconsin Regional Planning Commission and believes that the comprehensive plan for the Menomonee River watershed prepared by the Commission is a valuable guide, not only to the development of the watershed but also to the community, and the adoption of such plan by the (Name of Local Governing Body) will assure a common understanding by the several governmental levels and agencies concerned and enable these levels and agencies of government to program the necessary areawide and local plan implementation work.

NOW, THEREFORE, BE IT RESOLVED that, pursuant to Section 66.945(12) of the Wisconsin Statutes, the (Name of Local Governing Body) on the ___day of ___________, 197_, hereby adopts the comprehensive plan for the Menomonee River watershed previously adopted by the Commission as set forth in SEWRPC Planning Report No. 26 as a guide for watershed and community development.

BE IT FURTHER HEREBY RESOLVED, that the ____________ clerk transmit a certified copy of this resolution to the Southeastern Wisconsin Regional Planning Commission.

____
(President, Mayor, or Chairman of the Local Governing Body)

ATTESTATION:

____
(Clerk of Local Governing Body)

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ERRATA SHEET

Chapter III

Page 57, Map 7, legend, last line, should read: "channel realignment."

Chapter IV

Page 75, Map 9, legend, line 5, should read: "45 locations."
Page 77, Map 10, Menomonee River, R.M. 12.52: conditions 1 and 2 are incorrectly plotted.
Page 92, Map 15: LTMR -1 should be shown as a dashed line.
Page 127, Table 27, "No Action" alternative near top of table: "Total Annual Cost" should read "73.5" and "Annual Benefit Minus Annual Cost" should read "-73.5." "Detention Storage" alternative near top of table should read: "Resolve 51 percent . . ."
Page 157, Map 36, omit: red symbol near Freistadt Road.

Chapter V

Page 210, Table 39, right column, fourth line from bottom omit: "exposure."

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